2371

is also an essential component of myoglobin and various enzymes. Iron deficiency is the most common cause of anemia (Goodman and Gilman, 1985). Exposure to excessive levels of iron may cause gastrointestinal damage and dysfunction and enlargement of the liver and pancreas (Goodman and Gilman, 1985).

6.4.7.2.14 Lead

Lead is a soft, grey metal. Most of lead use is in the manufacture of storage batteries for motor vehicles and other power generators. In manufacturing, lead is used in ammunition, brass and bronze alloys, cable covering, solder, and ceramics.

The major organ systems affected by lead include the hematopoietic system, the central nervous system, the kidneys, and the gastrointestinal system. Effects on the hematopoietic system are recognized as one of the most sensitive of those induced by lead exposure. Clinically, anemia is the principal feature of lead intoxication, resulting from both increased erythrocyte destruction and decreased hemoglobin synthesis (ATSDR, 1993). The most insidious effects associated with lead intoxication are its central nervous system effects. Lead encephalopathy in both children and adults is characterized by restlessness, irritability, headache, loss of memory, and poor attention span. Convulsions, delirium, hallucinations, cerebral edema, and coma occur at later stages of intoxication (U.S. EPA, 1986). Low-level lead exposure has been related to decreased neuropsychological performance in groups of children with relatively moderate lead exposure compared with groups of children with lower lead exposure (ATSDR, 1993). Renal effects of lead include: (1) reversible proximal tubular damage, seen mainly with short-term exposure; and (2) reduced glomerular function, considered to be of a slow, progressive nature (ATSDR, 1993). The gastrointestinal system is one of the earliest to show symptoms of

lead intoxication, with colic (acute abdominal pain) a consistent early symptom of acute lead poisoning (ATSDR, 1993).

Lead is known to cross the placenta, and thus concern exists over distribution during pregnancy and possible toxic effects on the fetus (ATSDR, 1988). These effects were first indicated by high incidences of miscarriages and stillbirths in women working with lead during the latter half of the 19th century (U.S. EPA, 1986). More recently, environmental epidemiological studies have produced results suggestive of possible lead-induced reproductive and developmental effects that include reduced birth weight, reduced gestational age, and neurobehavioral deficits or delays (ATSDR, 1993).

The carcinogenicity of lead has been studied in experimental animals and has been evaluated in epidemiologic studies of lead-exposed workers. Ten rat bioassays and one mouse assay have shown significant excesses in tumor development following exposure to inorganic lead compounds (U.S. EPA, 1989). Epidemiology studies conducted on lead smelter workers have found significant excesses of respiratory and digestive cancers; however, the workers were exposed to a number of other toxic agents, thus preventing the establishment of a causal relationship. ATSDR (1993) concluded that the available human data from these occupationally-exposed workers are limited in usefulness. IARC (1987) concluded that there is sufficient evidence that certain inorganic lead compounds (lead acetate and subacetate) are carcinogenic in laboratory animals but that others, including metallic lead, lead oxide, and lead tetraalkyls, have not been adequately tested. IARC (1987) considered the human carcinogenicity data inadequate. Similarly, the U.S. EPA (1989) concluded that the animal data were sufficient to conclude that lead and lead compounds are probable human carcinogens, but that the epidemiologic evidence was insufficient.

2371

6.4.7.2.15 Lithium

Lithium is a solid metal and is widely distributed in nature. It can be found in trace amounts in many minerals and rocks, and in significant concentrations in natural water. Lithium is used in drugs, the production of high-energy batteries, lightweight alloys for aerospace applications, regulator rods in thermonuclear reactors, and organic reactions. Its presence in spa waters is thought to have a therapeutic effect (Birch, 1988).

By virtue of the fact that lithium is used as a drug (most commonly for treatment of psychological disorders) it is not a highly toxic metal. However, consumption of large quantities of lithium can result in diarrhea, vomiting, and even death. Side-effects associated with lithium therapy include loose stools, nausea, fine tremor, thirst, frequency of microurition, increased urinary volume, lethargy, muscular weakness, and electrocardiographic changes (ECG). Long-term side-effects include reduction in thyroid gland function, increased production of white blood cells, edema, weight gain, and mild memory impairment. Lithium effects the central nervous system and kidneys (Birch, 1988).

6.4.7.2.16 Magnesium

Magnesium is the eighth most abundant element in the earth's crust. It is an essential element in the diet of humans. Magnesium salts ingested in large quantities may cause vomiting or diarrhea. Inhalation of magnesium may result in metal-fume fever. Powdered magnesium metal can cause severe irritation to skin. Magnesium toxicity is primarily a concern in individuals with kidney failure (Birch, 1988).

2371

6.4.7.2.17 Manganese

Manganese is a naturally occurring metallic element found in many kinds of rock strata. Manganese is an essential element in the human diet. Manganese may be mixed with iron to form various metal alloys, and is also a component of different ceramic products, pesticides, and fertilizers (ATSDR, 1990).

The central nervous system is the primary target of manganese toxicity. Early CNS symptoms of manganese exposure may include headache, insomnia, disorientation, anxiety, lethergy, and memory loss (Francis, 1991). Inhalation of high levels of manganese compounds have been associated with a neurological condition known as "manganism," a disease characterized by weakness, apathy, progressive muscular problems, and potentially leading to a severe psychiatric disorder (ATSDR, 1990; Keen and Leach, 1988). This condition has been identified only in individuals occupationally exposed to high levels of manganese dust. Inhalation of airborne manganese particulates is the most common exposure route for humans. Pulmonary irritation and inflammation have been associated with individuals occupationally exposed to airborne manganese compounds such as manganese dioxide or tetroxide, although it is not clear whether the observed responses were due to manganese or the inhalation of particulate matter. Individuals exposed to manganese-containing dust regularly may also have an increased susceptibility to infections by bacterial pathogens (ATSDR, 1990; Francis, 1991). Keen and Leach (1988) noted that only two reports had been identified describing oral manganese toxicity in humans, which suggests that adverse health effects attributable to excess manganese ingestion are rare. Potential effects on reproduction (decreased fertility, impotence) have been observed in humans with inhalation exposure to manganese (Lauwerys et al., 1985; Francis, 1991) and in animals with oral exposure.

2371

6.4.7.2.18 Mercury

Mercury exists in many inorganic and organic compounds, as well as in its elemental form. According to NRC (1978), mercury compounds in the environment often occur as an insoluble sulfide, bound to soil or sediment through association with organic matter, or bound in inorganic complexes. Metallic mercury is rather volatile; in the workplace, exposure to mercury vapor is the most common form of occupational exposure to mercury. It is widely used in electrical apparatus and instruments, in dental preparations, and as a mildewcide and fungicide (Stokinger, 1981; Friberg, et al. 1986).

Ingestion of metal mercury is usually without effect (Goldwater, 1972). Ingestion of inorganic salts may cause severe gastrointestinal irritation, renal failure, and death. Mercury is also known to produce hypersensitivity reactions such as contact dermatitis and acrodynia (Young, 1992). Inhalation of mercury vapor may cause irritation of the respiratory tract, renal disorders, neurobehavioral changes and peripheral nervous system effects, and death (NIOSH, 1977; Young, 1992).

Little is known about the reproductive effects of elemental mercury in humans, although there have been case reports of spontaneous abortions and infant mortality among women exposed during pregnancy (U.S. EPA, 1980). Prenatal exposure to methyl mercury has been linked to fetal fatalities, and to neurological problems among survivors. There is some evidence that the fetus is more sensitive to the effects of methyl mercury than adults (WHO, 1976; Marsh et al., 1980; Inskip and Piotrowski, 1985).

Gale and Ferm (1971, as reported in U.S. EPA, 1980) reported teratological effects in animals exposed to mercuric chloride. Inorganic mercuric acetate is embryolethal and teratogenic to hamsters. Other adverse reproductive effects reported in animals include

inhibition of spermatogonial cells in mice treated with mercuric chloride (Lee and Dixon, 1975, as reported in U.S. EPA, 1980).

Rats given metallic mercury by intraperitoneal injection developed malignant sarcomas in tissues in direct contact with the metal (Druckey et al., 1957, as reported in U.S. EPA, 1980). Definitive data regarding the potential carcinogenicity of mercury or mercury compounds in animals or humans are unavailable (Young, 1992).

6.4.7.2.19 Nickel

Nickel is a naturally occurring element that can exist in several different oxidation states and in several different organic and inorganic forms. Most nickel enters the body via food and water consumption, although inhalation exposure in occupational settings may also be a primary exposure route. Human exposure to nickel may arise from disposal or incineration of wastes and from burning of fossil fuels. Although nickel is an essential trace element in various animal species, the biological importance of nickel in humans has not been established (NRC, 1989; Young, 1991).

Metallic nickel is relatively nontoxic, although acute inhalation exposure of human to high concentrations of nickel can result in headache, gastrointestinal disturbances, respiratory disorders, and death. Asthmatic conditions following inhalation exposure have been documented. Repeated inhalation exposure to some nickel compounds will cause effects of the respiratory tract and immune system. Toxic effects of oral exposure to nickel usually involve the kidneys. Nickel carbonyl is the most acutely toxic nickel compound, with the lung being the primary target organ. Acute exposure to nickel carbonyl can cause headache, nausea, chest pains, coughing, gastritis, and nervous system impairments, with chronic exposure leading to pathological lesions in the lung, liver, kidney, spleen and

brain. Contact dermatitis is often associated with exposure to nickel and nickel compounds. Continued exposure to nickel may lead to sensitization, with the development of conjunctivitis, asthma, pneumonitis, and local and systemic reactions (ATSDR, 1991; Young, 1991).

Adverse reproductive and developmental effects have been observed in experimental animals following exposure to various nickel compounds. Decreased fetal viability, increased numbers of malformations, and reduced growth rates were observed in offspring of animals exposed to nickel compounds (ATSDR, 1991). Nickel salts administered in drinking water over a three-generation reproduction study in rats have been shown to reduce litter size and increase offspring mortality. Degenerative changes of the testis have been observed in male rats administered nickel sulfate. Epidemiologic studies have shown that occupational inhalation exposure to nickel dust at refineries has resulted in increased incidences of pulmonary and nasal cancer (ATSDR, 1991; Young, 1991).

6.4.7.2.20 Potassium

Potassium is an essential nutrient in the human diet. Potassium, along with sodium, controls the passage of water in and out of cells and the electrical properties of cells. Unlike sodium, which remains on the outside of cells, potassium resides intracellularly. Although an imbalance of potassium in the body may cause serious illness or death, such an imbalance is unlikely to occur in relatively healthy individuals. Only those taking diuretics or with certain serious diseases may experience severe health effects resulting from excess excretion of potassium. Potassium may be an effective agent at lowering high blood pressure (Institute of Medicine, 1990).

6.4.7.2.21 Selenium

Selenium is a naturally occurring element found in soils worldwide in a number of different forms and in a number of different oxidation states. Selenium is an essential element in the human diet. Exposure to selenium can occur from eating contaminated foodstuffs or from emissions from various industrial processes.

Gastrointestinal absorption of selenium compound varies from approximately 50 to near 100 percent. Selenium compounds appear readily absorbed from the respiratory tract. In humans, acute oral exposure to high doses of selenium can result in excess salivation, garlic odor to the breath, shallow breathing, diarrhea, pulmonary edema, and death (Opresko, 1993). Additional acute toxic effects in animals include liver and kidney effects. Chronic oral exposures in humans have resulted in hair and nail loss, clubbing of the fingers, skin lesions, tooth decay, and nervous system abnormalities. Additionally, in animals, subchronic and chronic oral exposure to selenium has resulted in liver and kidney damage (Opresko, 1993).

Inhalation of selenium primarily affects the respiratory system. Mucous membrane irritation, bronchitis, and chemical pneumonia have been reported following inhalation of selenium-containing dusts (Opresko, 1993). Chronic effects of inhalation of selenium in humans or animals have not been reported.

Selenium is teratogenic in birds and several domesticated animal species, but data are not available in humans. Adverse reproductive and developmental effects have been observed in laboratory animals (Opresko, 1993). Epidemiology studies have failed to show an association between selenium and risk of death due to neoplasms (Opresko, 1993). Selenium sulfide has been identified as an animal carcinogen by the U.S. EPA (1994) in

mice studies following oral exposures. Data regarding carcinogenicity following inhalation exposure are not available (Opresko, 1993).

6.4.7.2.22 Silver

Silver is a relatively rare element that occurs naturally in the earth's crust and is released to the environment from various industrial sources. Although metallic silver is not regarded as toxic, many of the silver salts are toxic to a number of organisms.

In humans, ingestion of large doses of silver nitrate has produced corrosive damage of the gastrointestinal tract, abdominal pain, diarrhea, vomiting, shock, convulsions, and death (U.S. EPA, 1985). Ingestion, inhalation, or dermal absorption of silver may cause argyria, a permanent gray or blue-gray discoloration of the skin. In long-term oral studies with experimental animals, silver compounds have produced slight thickening of the membranes of the renal glomeruli, growth depression, and shortened lifespan (Matuk et al., 1981; Olcott, 1948, 1950).

Chronic inhalation of silver oxide and silver nitrate dusts may result in chronic respiratory irritation, deposition of granular silver in the eyes, impaired night vision, and abdominal pain (Rosenman et al., 1979; Faust, 1992). Mild allergic responses have been attributed to dermal contact with silver (ATSDR, 1990; Faust, 1992).

Data adequate for evaluating the carcinogenicity of silver to humans or animals by any exposure route are not available (Faust, 1992).

6.4.7.2.23 Sodium

Sodium is essential to human life. Similar to potassium, sodium controls the passage of water in and out of cells and controls the electrical properties of cells. Sodium is found in nearly all foods consumed by humans, whether it occurs naturally or is added as a flavor enhancer. Excess sodium in the diet has been linked to edema, hypertension, heart disease, and heart failure (Institute of Medicine, 1990).

6.4.7.2.24 Sulfide

Sulfide occurs as a salt (e.g., sodium, potassium, or calcium sulfide). Sulfur compounds occur naturally in the environment. The toxicity of a sulfide is a function of the metal to which the sulfur atom is bound. No toxicity information specific to sulfide was found in the available literature.

6.4.7.2.25 Thallium

Thallium is an element that occurs naturally in the earth's crust and is released to the environment by industrial sources. In the U.S., thallium is used in photoelectric cells, lamps, semiconductors, optical systems, scintillation counters, and as a catalyst in the oxidation of hydrocarbons and olefins. Exposure to thallium can occur via ingestion, inhalation, or dermal contact.

A number of thallium compounds have been shown to produce adverse effects in both animals and humans. The primary targets of thallium toxicity are the nervous system, the skin, and the reproductive system (Borges and Daugherty, 1991). Acute exposure to thallium in humans leads to polyneuritis, gastrointestinal symptoms, tachycardia, ataxia,

paresthesia, changes in the central, peripheral, and autonomic nervous systems, alopecia, and kidney necrosis. Chronic exposure to thallium results in alopecia in animals and humans. Early symptoms of long-term exposure to thallium include fatigue, limb pain, alopecia, peripheral neuritis, proteinuria and joint pain (ATSDR, 1990).

An increased incidence of congenital malformations was observed in children whose parents were exposed to thallium through the consumption of home-grown vegetables and fruit, but a causal relationship between these effects and thallium could not be verified (Dolgner et al., 1983). Some animal studies have shown testicular effects in treated males, slight signs of fetotoxicity, and significant impairment of learning ability in the offspring of treated animals (ATSDR, 1990; Borges and Daugherty, 1991).

Data adequate for evaluating the carcinogenicity of thallium to humans or animals by any exposure route are not available (Borges and Daugherty, 1991).

6.4.7.2.26 Vanadium

Vanadium is a grayish white metal that is widely distributed at low concentrations in the earth's crust. Vanadium is used as an alloying agent in steel and non-ferrous metals, and as a catalyst in chemical, ceramic, or specialty applications.

Vanadium compounds are poorly absorbed through the gastrointestinal system, but are slightly more readily absorbed through the lungs (Opresko, 1991). The toxicity of vanadium depends highly on its valence state and solubility. Effects observed following acute oral exposures in experimental animals include vasoconstriction, fatty degeneration of the liver and kidneys, hemorrhage, and bone marrow changes (U.S. EPA, 1987; ATSDR, 1990; Opresko, 1991). Subchronic and chronic oral exposures in animals and

humans indicate that primary targets are the digestive system, kidneys, and blood (Opresko, 1991).

Adverse health effects have been seen in workers exposed to large amounts of airborne vanadium pentoxide dust. Effects included coughing, wheezing, breathing difficulties, bronchitis, chest pains, eye irritation, and skin irritation. Although most symptoms disappeared after exposure ceased, workers may be sensitized such that there is increased severity and more rapid onset of symptoms during subsequent exposures (Opresko, 1991).

There is little evidence that vanadium or vanadium compounds are reproductive toxins or teratogenic. There are very few adequate studies to evaluate the carcinogenicity of vanadium (Opresko, 1991).

6.4.7.2.27 Zinc

Zinc is a naturally occurring metal commonly found in air, soil, water, and various foodstuffs. It is an essential element in the human diet. Zinc, in a variety of inorganic forms, is a component of a number of different industrial processes and products, including the plastics industry, batteries, wood preservatives, fire retardants, and rodenticides (Bertholf, 1988). Exposures to airborne zinc can occur in the vicinity of galvanizing, smelting, or foundry operations.

The toxicity of zinc is considered to be relatively low. Ingestion of excessive levels of zinc in humans may lead to nausea, vomiting, epigastric distress, and anemia. Intestinal hemorrhage and pancreatic alterations have been observed in animals fed high levels of zinc compounds (ATSDR, 1988). Chronic oral exposures to zinc have resulted in certain anemias in humans, and there is also limited evidence that the human immune system may

be impaired by subchronic oral exposure to zinc (including zinc taken as a dietary supplement) (Opresko, 1992).

Inhalation of high concentrations of zinc can cause metal fume fever, characterized by rapid breathing, shivering, fever, sweating, generalized weakness, and temporary impairment of pulmonary functioning, has been observed in workers exposed to certain zinc vapors (Bertholf, 1988; ATSDR, 1988).

Oral exposure to high levels of zinc has been shown to reduce fetal growth rate and to reduce reproductive success in exposed animals (ATSDR, 1988; Opresko, 1992). No epidemiologic data are available to evaluate the carcinogenicity of zinc in humans. Two studies of zinc in the food or water of mice did not result in excess cancers, while another longer-term study in mice did observe increased tumor frequencies following exposure to zinc in water (Opresko, 1992).

6.4.7.3 Radionuclides

6.4.7.3.1 Uranium

Uranium is a mildly radioactive element that occurs widely in the earth's crust. It is found in all soils, most rocks and, in lesser concentrations, in water, vegetation, and animals, including humans. Uranium emits a low level of alpha particles and a much lower level of gamma rays. Alpha particles are unable to penetrate skin, but can travel short distances in the body if ingested or inhaled. Consequently, uranium represents a significant carcinogenic hazard only when taken into the body, where alpha particle energy is absorbed by small volumes of tissue. Although the penetrating (gamma) radiation of uranium is not considered to be significant (ATSDR, 1989), one of its daughter radionuclides is a strong

gamma emitter. Therefore, gamma radiation may be a concern in areas containing uranium.

Natural uranium contains the uranium isotopes uranium-238 (which averages 99.27% of total uranium mass), uranium-235 (0.72%), and uranium-234 (0.0056%), each of which undergoes radioactive decay. Natural uranium, therefore, contains the radionuclide daughter products from the decay of uranium-238 and uranium-235 (Bowen, 1979; ATSDR, 1989). (NOTE: The principal process at PORTS is the separation of uranium isotopes through gaseous diffusion and the enrichment of uranium-235. It was therefore considered possible that uranium released as a result of facility operations would not contain uranium isotopes at their naturally occurring ratios. Isotopic analyses performed on 5 percent of the analyzed samples, however, provide no evidence that the abundance of uranium isotopes differs from that of uranium natural.)

Uranium is a radioactive element, but it is also a metal element. Toxicological effects from the ingestion of uranium are the result of the action of uranium as a metal and its radioactive properties. The primary toxic chemical effect of uranium is seen in kidney damage. Studies in rabbits, mice, and dogs showed effects on the kidney to be dose-related. Fetal skeletal abnormalities and fetal death were found in pregnant mice exposed to 6 mg/kg or uranyl acetate dihydrate.

The primary human exposure studies to uranium have been of uranium miners or uranium factory workers. These studies have shown an increase in lung cancer deaths among these workers, which may be attributable to the decay of uranium into radon and its daughters. These workers are exposed to high levels of uranium dust and fumes, and other radioactive elements in confined conditions (ATSDR, 1989).

(NOTE: Because most samples of PORTS site media were routinely analyzed for total uranium [in mass of uranium/mass medium], the above analysis of weight fraction of individual isotopes, as well as knowledge of specific activity of the individual isotopes must be integrated with the isotope-specific fatal cancer risk factor [in units of pCi^{-1}] to generate estimates of cancer risk. This procedure is discussed in detail in Section 6.3.4.3.)

6.4.7.3.2 Technetium

Technetium (Tc) is a radioactive element that occurs in a number of isotopic forms. Technetium is found in some extraterrestrial material (i.e., stars); however, no appreciable amounts have been found in nature due to the relatively short half-lives of its radioactive isotopes (Kutegov et al., 1968). While no isotopes of technetium are stable, the existence of three technetium isotopes is well established. Two common forms of technetium, technetium-97 and technetium-98, have half-lives of 2.6×10^6 and 1.5×10^6 years, respectively. The third isotope, technetium-99, has a half-life of 2.12×10^5 years (Peacock, 1973, as cited in Bailer et al., 1973). None, however, possesses a half-life sufficiently long to allow technetium to occur naturally (Boyd, 1959). Technetium is made artificially for industrial use, and natural technetium, particularly technetium-99, has been identified and isolated from the spontaneous fission of uranium, as well as other fissionable material or via the irradiation of molybdenum (Venugopal and Luckey, 1978; Peacock, 1973, as cited in Bailer et al., 1973; Clarke and Podbielski, 1988, as cited in Seiler et al., 1988). (NOTE: At PORTS, technetium-99 is present as a trace impurity from recycled uranium used in the gaseous diffusion process.)

Technetium is an emitter of beta particles of low specific activity (Boyd, 1959). It does not release nuclear energy at a rate sufficient to make the element attractive for the conventional applications of radioactivity (Boyd, 1959). Technetium-99 is the only long-

lived isotope that is readily available and is the isotope on which most of the chemistry of technetium is based (Peacock, 1973, as cited in Bailer et al., 1973). Although gamma radiation has not been associated with technetium-99, the secondary X-rays may become important with larger amounts of the element (Peacock, 1973, as cited in Bailer et al., 1973).

6.5 Risk Characterization

6.5.1 Introduction

Risk characterization is the final step of the human health risk assessment process. In this step, the toxicity and exposure assessments are integrated to estimate quantitatively and qualitatively both carcinogenic and noncarcinogenic health risks. The methodology for deriving quantitative risk estimates is presented in Section 6.5.2. Section 6.5.3 presents the baseline risk estimates for the current and future use scenarios addressed in this risk assessment.

The numerical risk estimates that are presented in this section must be interpreted in the context of the uncertainties and assumptions associated with each step of the risk assessment process and with the data upon which the risk estimates are based. The major uncertainties and assumptions associated with the assessment of potential risk of contaminants in Quadrant III media are discussed in Section 6.5.4.

6.5.2 Methodology for Quantitative Risk Estimation

6.5.2.1 Hazard Index for Noncancer Effects

The numerical estimate of the potential for noncancer effects is derived as the ratio of the chronic daily intake (CDI) to the chronic RfD. This ratio is also referred to as a Hazard Quotient (HQ):[6]

$$HQ = \frac{CDI}{RfD}$$

where:

HQ	=	Hazard quotient
CDI	=	Chronic daily intake, mg/kg/day
RfD	=	Reference dose, mg/kg/day

If the HQ is less than or equal to one, the estimated exposure to a substance, represented by the CDI, is judged to be below the threshold that could possibly result in

---

[6] For evaluating risks from inhalation exposure, this equation is modified slightly because the RfC and the estimate of exposure are expressed in terms of the concentration in air in units of mg substance/m^3 air. Thus, for inhaled toxicants, the HQ is calculated as:

$$HQ = \frac{C_a}{RfC}$$

where:

C_a	=	Concentration in air, mg/m^3
RfC	=	Reference concentration, mg/m^3

a toxic effect. If the HQ is greater than one, a noncancer risk may or may not result, depending upon the size of the HQ and the relative size of the safety factors that have been incorporated in deriving the RfD.

The assessment of overall potential for noncancer effects posed by simultaneous exposure to multiple chemicals from several sources by more than one pathway is conducted using the Hazard Index (HI) approach developed in U.S. EPA's Guidelines for the Health Risk Assessment of Chemical Mixtures (U.S. EPA, 1986) and described in RAGS (U.S. EPA, 1989a). As an initial screen, the HQ values for individual chemicals associated with a given exposure pathway are summed to provide an indication of the potential for noncancer effects posed by multiple chemical exposure. The sum of the HQ values for individual chemicals is referred to as the HI. As described in U.S. EPA (1989a), the HI values for individual exposure pathways can also be combined, as appropriate, to provide an indication of the overall potential for noncancer effects for individuals exposed to site contaminants by more than one pathway (e.g., an individual exposed by incidental soil ingestion, dermal contact with soil, and ingestion of groundwater). The HI approach assumes that multiple sub-threshold exposures (exposures below the RfD) could result in an adverse effect and that a reasonable criterion for evaluating the potential adverse effects is the sum of the hazard quotients (U.S. EPA, 1986).

If the HI is one or less, cumulative exposure to the contaminants of concern would not be expected to result in adverse effects. If the HI is greater than one, there is an increased potential for adverse effects under the assumed exposure conditions. An HI greater than one, however, does not necessarily indicate that the multiple exposure would result in adverse noncancer effects in the exposed population. The assumption of additive effects reflected in the cumulative HI is most properly applied to substances that induce the same

effect by the same mechanism (U.S. EPA, 1986). Application of the HI approach to a mixture of substances that are not expected to induce the same type of effects could overestimate the potential for adverse health effects. In the current assessment, with the exception of one data set, this refinement of the HI approach was not performed; i.e., the cumulative HI was calculated irrespective of the mechanism of action of individual chemicals. The potential for this approach to result in overestimates of potential hazard at the PORTS site is discussed further in Section 6.5.4.

In the case of one Quadrant III data set, the HI exceeded one only as a consequence of summing several HQ values that were each less than one. For this data set, segregation of HQs by toxic endpoint was performed. The results of this analysis are presented in Section 6.5.4.2.

In summary, the HI provides a rough measure of potential toxicity, but it is dependent on the quality of the experimental evidence. It is important to remember that the HI does not define a dose-response relationship, and does not represent a statistical probability of incurring an adverse effect (U.S. EPA, 1986).

6.5.2.2 Cancer Risk for Chemicals

The numerical estimate of the excess lifetime cancer risk resulting from oral exposure to chemical carcinogens can be calculated by multiplying the CDI by the risk per unit dose, or SF, as follows:[7]

---

[7] For characterizing excess cancer risks associated with inhalation exposure, this equation is modified slightly because the measure of carcinogenic potential for carcinogens by inhalation (i.e., the unit risk) is expressed as risk per unit concentration in air or
$(\mu g/m^3)^{-1}$. Thus, risk for inhaled carcinogenic chemicals is calculated as follows:

$$Risk = CDI \times SF$$

where:

Risk	=	Lifetime probability of developing cancer due to exposure to the chemical carcinogen
CDI	=	Chronic daily intake, mg/kg/day
SF	=	Cancer slope factor, $(mg/kg/day)^{-1}$

The result of this evaluation for chemical carcinogens is an upper-bound estimate of the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen.

As noted in U.S. EPA (1989a), this linear equation is valid only at low excess cancer risk levels (i.e., below estimated risks of 10^{-2} or 0.01). Where calculated risks are in excess of 10^{-2}, U.S. EPA (1989a) recommends that an alternative one-hit equation be used. The one-hit equation is as follows:

$$Risk = 1 - \exp(-CDI \times SF)$$

$$Risk = C_a \times Unit\ Risk$$

where:

C_a	=	Concentration in air, $\mu g/m^3$
Unit Risk	=	Risk per unit concentration in air, $(\mu g/m^3)^{-1}$

At high risk levels, the results of the linear risk equation and the one-hit equation do not produce the same result. Rather than apply the one-hit equation, **however,** situations with high carcinogenic risk levels (i.e., risks that exceed a level of 10^{-2}) have been flagged in the text and in risk summary tables as "$>10^{-2}$."

An estimate of the upperbound on excess lifetime cancer risk from simultaneous exposure to multiple carcinogens from more than one exposure pathway is based on the guidelines provided in U.S. EPA (1986) and U.S. EPA (1989a). Specifically, total excess lifetime cancer risk is estimated as a sum of the risks from individual chemical carcinogens. Limitations to this approach for estimating the upper bound on total excess lifetime cancer risk are discussed in the section on uncertainties and limitations in the risk assessment process (Section 6.5.4).

Generally, regulatory agencies have judged excess cancer risk estimates less than one in one million (10^{-6}) to be insignificant. Under RCRA's corrective action program (U.S. EPA, 1990a) and OEPA's policy stated in "How Clean is Clean?" (OEPA, 1991), U.S. EPA and OEPA have established a cancer risk level of 10^{-6} as the point of departure for determining the most appropriate risk level that remedial programs should be designed to attain. This goal is not a strict presumption that the final cleanup will attain that risk level. The ultimate decision of an appropriate level of protection depends on a variety of site-specific or remedy-specific factors. Under the corrective action program, however, the risks to an individual should not exceed a risk level of approximately 10^{-4} (U.S. EPA, 1990a). In the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300), U.S. EPA states that: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response." A one in one million excess lifetime cancer

risk means that an average individual exposed under the assumed conditions has an extra chance of 1 in a million of developing a cancer during his or her lifetime, as a result of the exposure. To the extent that the cancer risks are conservatively estimated, the true risk may be lower, and possibly zero.

In the analysis of cancer risk levels estimated for Quadrant III media (see Section 6.8), excess lifetime cancer risks are compared to "target risk levels" of 10^{-4} and 10^{-6} consistent with the policies established under RCRA, CERCLA, and OEPA's policy "How Clean is Clean?".

6.5.2.3 Cancer Risk For Radionuclides

Quantification of cancer risk for radionuclides is conceptually similar to quantification of risks for chemical carcinogens. Lifetime cancer risk is calculated by multiplying the intake of the radionuclide by the route-specific cancer SF. Thus, the cancer risk for a radionuclide is estimated as follows:

$$Risk = I \times SF$$

where:

Risk	=	Excess lifetime cancer risk due to intake of the radionuclide by ingestion (or inhalation)
I	=	Lifetime intake of the radionuclide by ingestion (or inhalation), pCi
SF	=	Cancer slope factor for the radionuclide by ingestion (or inhalation), $(pCi)^{-1}$

Potential risk associated with external exposure to radionuclides in soil is calculated similarly, with intake measured in units of yr • Ci/g soil and the SF expressed in units of $(yr \bullet Ci/g\ soil)^{-1}$.

As with chemical carcinogens, the total lifetime cancer risk from exposure to multiple radionuclides and multiple pathways is calculated as a sum of individual radionuclide risks.

6.5.2.4 Cumulative Cancer Risks from Chemical Carcinogens and Radionuclides

Estimates of excess lifetime risk from radiological and chemical risks have been summed in order to determine the overall potential health risks associated with each SWMU. Total excess lifetime cancer risks associated with radionuclides and chemical carcinogens were calculated, recognizing the limitations in combining such risks because of the differences in cancer SFs for radionuclides and chemical carcinogens. These limitations are examined further in the discussion of uncertainties in the risk assessment process, Section 6.5.4.

6.5.2.5 Risk Characterization for Lead

As discussed previously, the evaluation of risks associated with exposure to lead requires the use of the IEUBK model for lead in children, which predicts blood lead concentrations in children exposed to lead through a variety of media. The model is designed to estimate blood lead levels using a combination of default exposure assumptions and exposure concentrations combined with site-specific exposure information where available.

This assessment was done using version 0.99D of the computerized IEUBK model (U.S. EPA, 1994c), which is calibrated for children up to seven years of age. Uptake of lead from five media (air, drinking water, soil/dust, food, and paint) are considered by the model. For this assessment, blood lead levels for children from 0.5 to 7 years of age were modeled. According to U.S. EPA, the Centers for Disease Control (CDC), and other regulatory bodies, low-level exposure to lead during infancy and childhood increases the risk of irreversible neurobehavioral deficits at levels of internal exposure as low as 10 μg/dL (CDC, 1991; NRC, 1993; U.S. EPA, 1989d; and ATSDR, 1993). In general, U.S. EPA regions have recently considered acceptable exposures as those that correspond to a blood lead level of 10 μg/dL or less in 95 percent of exposed children. At certain Superfund sites, however, a higher value, the 15 μg/dL blood lead level, has been used as a criterion of no significant risk (see for example the Record of Decision for the NL Industries/Taracorp Site -- U.S. EPA Region V). For this assessment, we have conservatively applied the acceptable criterion of a blood lead level of 10 μg/dL or less in 95 percent of exposed children.

The IEUBK model predicts as its output a probability curve around the geometric mean blood lead concentration, from which the 95th percentile of the children's blood lead concentration can be determined. The most appropriate exposure input for the IEUBK model is the value that represents the central tendency of the lead concentration (e.g., arithmetic or geometric mean). In this assessment, the maximum soil lead level in each SWMU was used as a highly conservative estimate of the average SWMU soil lead concentration. Use of the SWMU-specific maximum soil lead levels was considered appropriate (rather than the average soil lead level) because average (arithmetic mean) soil lead levels in all SWMUs were below tentative background (i.e., the UCL). In fact, all maximum soil lead levels were below the default soil lead level in the IEUBK model of 200 mg/kg. In addition, a preliminary assessment of groundwater lead levels was conducted.

A more thorough consideration of potential risks posed by lead in groundwater will be performed in the CAS/CMS as part of the re-evaluation of inorganic constituents using the background analysis presented in the BSI.

Input data used in the IEUBK model are presented in Appendix H.6 (default values were used for all data except for soil/dust). It was assumed that dust lead levels would equilibrate to soil lead levels. The potential blood lead levels and distributions associated with exposure to lead were evaluated separately for background soil lead levels and for soil lead levels measured in each SWMU. Figures showing the predicted probability density functions for background and SWMU-specific soil lead levels and for groundwater lead levels are presented in Appendix H.6. A summary of the results of the UBK model is included in Section 6.5.3.5 below.

6.5.2.6 Assessment of Acute Toxicity

As indicated in Section 6.4.6, an assessment of potential for acute toxic effects occurring as a result of exposure to constituents present in PORTS environmental media was limited to chemicals present in surface water and groundwater. The assessment took the form of a screen, in which maximum concentrations of each constituent present in surface water or groundwater were compared to one- and ten-day Health Advisories (U.S. EPA, 1993a). Exceedence of an advisory would indicate some potential for acute toxicity. Because surface water and groundwater present in Quadrant III are not potential sources of drinking water, an assessment of surface-water and groundwater concentrations for chemicals of concern by comparison to short-term Health Advisories is highly conservative.

6.5.3 Risk Estimates

Risk estimates are summarized and discussed in the following sections. A complete presentation of risk estimates for each scenario and SWMU by chemical is provided in Appendix H.7. It must be emphasized that the risks estimated using these risk assessment methods are not actuarial; i.e., the risk estimates cannot be used to predict the actual number of individuals who might experience health consequences as a result of exposure. Actual health risk is almost certainly less than that described using the methods of risk assessment.

6.5.3.1 Overview

Quantitative estimates of potential carcinogenic and noncarcinogenic risk to constituents in Quadrant III based on data collected during the RFI are presented in Sections 6.5.3.2 to 6.5.3.9 below. Potential risks associated with background levels of inorganic constituents in soil are presented in Section 6.5.3.2. Section 6.5.3.4 presents estimates of potential risk based on constituent levels present in each SWMU. In addition, for selected scenarios, estimates of potential risk based on average constituent levels present in the quadrant as a whole were calculated; these risks are presented in Section 6.5.3.3. In the discussion of risk in each of these sections, "driver" chemicals are identified for pathways with HI values that exceed 1 or excess cancer risk values greater than 10^{-6}.

The potential for adverse effects associated with lead levels in soil and groundwater is described separately in Section 6.5.3.5, because the approach for characterizing risks associated with lead exposure differs from the approach applied to other substances. Section 6.5.3.6 presents the results of the screening approach used to assess potential risks

from exposure to beta-emitting radiation. An assessment of potential for acute toxicity associated with on-site constituents is presented in Section 6.5.3.7.

Off-site data were not collected as part of the RFI. A qualitative assessment of potential off-site exposures is provided in Section 6.5.3.8 based on environmental surveillance data collected and published by Martin Marietta Energy Systems. Section 6.5.3.9 presents an analysis of risks for potential laboratory contaminants.

Quantitative assessments of potential risk were conducted based on total constituent concentrations for those constituents present at concentrations in excess of tentative background. In other words, maximum concentrations of naturally occurring inorganic constituents were compared to tentative background values. If the maximum concentration was less than the tentative background value, the compound was not included in the quantitative risk assessment (i.e., the compound was "screened" from the assessment). Estimates of potential risk were developed for all chemicals not screened from the assessment. Because tentative background values were available only for constituents in soil, this procedure was applied to RFI data for constituents present in soil only. In the absence of tentative background values for groundwater, surface water, and sediment, no constituents present in these media were "screened" from the risk assessment.

In addition, estimates of "incremental" risk were calculated. Incremental risks were developed to distinguish, for naturally occurring constituents present at concentrations above tentative background, that portion of the risk estimate likely attributable to background and that portion of the risk estimate likely attributable to facility activities. If, for example, arsenic was present in a soil sample at a concentration of 23.5 mg/kg and tentative background for arsenic in soil was 23 mg/kg, it is likely that a significant portion of the arsenic soil concentration could be naturally occurring and not the result of facility

operations. Incremental risks were calculated by subtracting risks associated with background levels of naturally occurring inorganic constituents in soil from risks associated with total constituent levels. The resulting risk (i.e., incremental risk) was that measure of risk associated with the concentration of a constituent in excess of background. (It is noted again that at the time of the quantitative risk assessment, tentative background analyses were available for inorganic constituents in soil only. Therefore, total and incremental risks are the same for all organic chemicals in all media, and for inorganic chemicals in groundwater, surface water and sediment.)

In assessing the noncarcinogenic risks of chemicals, HI values have been calculated for all pathways using adult parameters and, in addition, using child parameters for those pathways (i.e., ingestion of soil, sediment, and milk) where child exposure adjusted for body weight may be greater than adult exposure. Both adult and child HI values are presented, as appropriate, in the summary tables of potential risks for each of the units evaluated. (HI values for the child are presented in footnotes to the summary risk tables). The sum of the HI values for multiple exposure routes is based on adult exposures.

6.5.3.2 Estimates of Potential Risk for Background

This section presents estimates of potential risk associated with levels of naturally occurring inorganic substances in background soil samples. As the results of this analysis show, even naturally occurring compounds present a quantifiable risk, which, under some exposure conditions, exceeds U.S. EPA target risk levels.

It should be noted that soil background levels of inorganic compounds and uranium used in the current assessment are tentative background values developed prior to the completion of the BSI (U.S. DOE, 1996a). Further consideration of background-associated

risk based on background values presented in the BSI will be incorporated into the CAS/CMS. While use of tentative soil background values introduces some uncertainty in the quantification of background risk, the degree of uncertainty was considered less than that resulting from failure to consider background contributions at all. Reanalysis of Quadrant III data using approved background analyses presented in the BSI may result in the addition or removal of chemicals of potential concern from the risk assessment. The estimation of risks may be affected, depending on whether chemicals of potential concern are added or removed.

At the time of the quantitative risk assessment, background levels for inorganic compounds and uranium in groundwater, surface water, and sediments were not established. Therefore, no background risks are estimated for these media. It is likely, however, that some of the risks associated with inorganic compounds and uranium in on-site groundwater, surface water, and sediment are attributable to naturally occurring levels of these compounds.

6.5.3.2.1 Recreational Population

Summary risk estimates for the future recreational exposure scenario exposed to tentative background levels of inorganic chemicals are presented in Table 6.175. Risk estimates have been calculated for indirect exposures to inorganic chemicals in soils (specifically, ingestion of game grazed on on-site soils).

The HI for background for the recreational population associated with ingestion of local game that grazed on-site is less than one ($HI = 3 \times 10^{-2}$) and the excess lifetime cancer risk level is 3×10^{-7}.

6.5.3.2.2 On-Site Worker

Summary risk estimates associated with background under the current on-site worker scenario (assuming potential exposure to soil only) and the future on-site worker scenario (assuming potential exposure to soil and groundwater) are presented in Tables 6.176 and 6.177. Because background analyses for groundwater were not available at the time of this assessment, the risk estimates developed for the current and future on-site worker, both of which are based on background levels in soil, are the same.

The total HI for background for the on-site worker is 5. This HI value is largely attributable to dermal absorption of manganese in soil. The total excess lifetime cancer risk is 3×10^{-5}. This excess risk is attributable to exposure to arsenic and beryllium in soil via incidental ingestion and dermal contact.

6.5.3.2.3 Future On-Site Resident

Summary risk estimates for the future on-site resident exposed to tenative background levels of inorganic chemicals are presented in Table 6.178. Risk estimates have been calculated for residential exposures involving direct and indirect contact with soils and recreational exposures also involving indirect contact with soils (i.e., ingestion of game grazed on on-site soils).

The total HI for all pathways is 20. This HI value is attributable to both direct and indirect exposure pathways, including incidental ingestion of and dermal contact with soil, and ingestion of vegetables, beef and milk. Noncancer risks are driven by tentative background levels of manganese in soil.

The total excess lifetime cancer risk for background under future on-site residential exposure conditions is 2×10^{-4}. This risk level is largely attributable to incidental ingestion of soil, dermal contact with soil, and ingestion of vegetables, beef, and milk. Potential risks are driven by background levels of arsenic and beryllium in soil.

6.5.3.2.4 Excavation Worker

Summary risk estimates for the excavation scenario based on exposure to background tentative levels of inorganic chemicals are presented in Table 6.179. Risk estimates have been calculated for exposures involving direct soil contact and inhalation of contaminants present in airborne soil particulates.

The total HI for background for the excavation worker is 4. This risk is largely attributable to incidental ingestion of soil, with the risk driven by exposure to tentative background levels of manganese. The total excess lifetime cancer risk is 3×10^{-6}. This excess risk is largely attributable to ingestion of soil, with the risk driven by exposure to arsenic. Dermal contact with soil (4×10^{-7}) and inhalation of airborne soil particulates (7×10^{-7}) also contribute to total risk, although the risks associated with these latter two pathways do not exceed a 10^{-6} risk level.

6.5.3.3 Estimates of Potential Risk for the Quadrant

For selected scenarios, estimates of potential risk have been calculated based on average concentrations of chemicals of potential concern across the quadrant. Specifically, assessments of risks associated with ingestion of beef and milk by the future on-site resident and ingestion of game by the recreational population have been performed based on average soil concentrations of chemicals of potential concern in Quadrant III rather than average

concentrations present in individual SWMUs. These pathways were evaluated using quadrant-wide average concentrations because it is unreasonable to assume that cattle or deer can be confined to individual SWMUs.

Quadrant-wide risks were also calculated for the recreational population. The recreational population risk estimate based on quadrant-wide average concentrations was used in the assessment of potential risks for a future on-site residential population that also engaged in recreational activities across Quadrant III. Thus, the recreational risk estimate based on quadrant-wide average concentrations was added to each of the SWMU-specific risks based on residential exposures.

The quadrant-wide risks have been based on total concentrations of each constituent in the relevant medium and, for naturally occurring inorganic compounds for which tentative background analyses have been performed, on the incremental concentration above background. As noted previously (Section 6.5.3.2), background levels were not available at the time of this assessment for groundwater, sediment, or surface water. It is likely, however, that risks associated with these on-site media are attributable at least in part to naturally occurring levels of inorganic compounds.

6.5.3.3.1 Ingestion of Beef and Milk

Potential risks associated with beef and milk ingestion have been included in each of the SWMU-specific risk assessments. Because it is not reasonable to assume that cattle could be grazed on individual SWMUs, the risks for beef and milk ingestion have been calculated based on quadrant-wide average concentrations. These quadrant-wide risks have been added to the SWMU-specific risks. The risks for beef and milk are presented in Table 6.180. As this table shows, the total HI for these pathways is 4×10^{-1}, and the total

excess cancer risk is 3×10^{-4}. This excess cancer risk is driven by PCBs, PAHs, gamma-chlordane, and technetium.

6.5.3.3.2 Recreational Population

Current Use: Off-Site Recreational Population

Summary risk estimates for the recreational exposure scenario under current use conditions are presented in Table 6.181. Risk estimates are based on exposure via ingestion of local game, the only potential route of exposure for the recreational population considered under current use conditions. (Note: Modeled concentrations are based on exposure to soils at 0 to 2 ft bgs.)

The total HI for ingestion of game is 5×10^{-4}. The excess lifetime cancer risk level is 9×10^{-8}.

Future Use: Off-Site Recreational Population

Summary risk estimates for the off-site recreational exposure scenario under future use conditions are presented in Table 6.182. As for the current use scenario, risk estimates are based on exposure via ingestion of local game. [Note: Modeled concentrations are based on exposure to soils at 0 to 10 ft bgs.]

The total HI for ingestion of game is 5×10^{-4}. The total excess lifetime cancer risk level is 9×10^{-8}.

Future Use: On-Site Recreational Population

Summary risk estimates for the on-site recreational exposure scenario under future use conditions based on quadrant-wide average concentrations are presented in Table 6.183. Risk estimates for the on-site recreational population are based on exposure via direct contact with surface water and sediments, and ingestion of local game.

The total HI for all pathways is 4. This HI is driven by dermal contact with surface water containing manganese. The total excess lifetime cancer risk is 3×10^{-4} and is driven by exposure to PCBs (Aroclor-1260), PAHs, arsenic and beryllium in sediment via incidental ingestion and dermal contact. Risks in excess of 10^{-6} are also presented by exposure to benzo(a)anthracene, 1,2-dibromo-3-chloropropane, arsenic, and beryllium in surface water (via incidental ingestion and dermal contact).

6.5.3.4 Estimates of Potential Risk by SWMU

Estimates of potential risk by SWMU are presented in the remainder of this section. Because of the limited number of samples taken from most SWMUs, risks are based on average SWMU-specific concentrations conservatively estimated as the maximum detected concentration in that SWMU. For each SWMU and each population, risks are presented as both total risks and incremental risks.

For SWMUs for which soil data were collected, potential risks were evaluated for a current on-site worker and a future on-site worker, a future on-site resident, and an excavation worker. A consistent set of assumptions was applied to all SWMUs in the estimation of potential risk for these populations. As previously noted, these exposure scenarios were not entirely appropriate for a limited number of SWMUs (e.g., drainage

ditches, holding ponds and containment ponds); in these cases, exposure and risk estimates were considered highly conservative.

Of the scenarios developed for characterizing potential risk, that for the future on-site resident is the most complex and bears additional discussion here. The risk estimates for the future on-site resident include a combination of SWMU-specific and quadrant-wide average risks. SWMU-specific risks associated with groundwater exposure and with direct and indirect exposure to chemicals of potential concern in soil have been calculated. Because it is unreasonable to assume that a single SWMU could support cattle, risks associated with beef and milk on a quadrant-wide basis have been added to each of the SWMU-specific risks. It is also possible that the future on-site resident could engage in on-site recreational activities. Therefore, potential risks for the future on-site recreational population estimated on a quadrant-wide basis have also been added to each of the SWMU-specific risks. It should be noted, however, that it is highly unlikely that an individual exposed as a resident under RME conditions would also be exposed during recreational activities under RME conditions.[8]

Finally, to assist the reader, two tables have been prepared to serve as "road maps" to the assessments of each of the SWMUs. The first of these two tables, Table 6.133,

---

[8] It is highly unlikely that an individual could be exposed both as a resident to constituents in media from an individual SWMU under RME conditions (i.e., 24 hours/day for 350 days) and during recreational activities to constituents at average concentrations across the quadrant under RME conditions (i.e., 90 days). The exposure times alone result in exposures of greater than 365 days annually. Further, exposures associated with an RME scenario are calculated by setting several of the individual exposure parameters at the 90th or 95th percentile. Combining relatively more upper 90th (or 95th) percentile values, as one does in combining the estimates of potential risk for a resident and an individual engaged in recreational activities, can result in exposure and risk estimates well above the range that can reasonably be expected (e.g., see U.S. EPA, 1990b).

identifies the specific exposure scenarios used to assess risks for individual SWMUs. Any alternative exposure scenarios used to assess data sets to which the standard set of assumptions did not apply are noted. The second table, Table 6.184, provides the number of the section in the text where a discussion of potential SWMU-specific risks appears, the table numbers that provide summary risk estimates, and the appendix location that provides tables of chemical-specific risk estimates.

(Note: In the following tabular risk discussions, excess cancer risk is abbreviated ECR.)

6.5.3.4.1 X-230J3 West Environmental Sampling Building and Intermittent Containment Basin

The X-230J3 West Environmental Sampling Building is a structure housing monitoring equipment and controls for the gates of the intermittent containment basin. The containment basin has gates that can be closed to impound the flow in the West Drainage Ditch before it crosses under the perimeter road.

Summary risk estimates for the X-230J3 unit by exposure scenario are presented in Tables 6.185 to 6.189 and are discussed below. Estimated risks associated with this SWMU are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: X-230J3 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 8×10^{-2}. Incremental HI = 6×10^{-2}.	Total ECR = 3×10^{-4}. This ECR is driven by exposure to soil containing PAHs. Risks in excess of 10^{-6} are also presented by external radiation exposure associated with uranium levels in soil (2×10^{-6}). Incremental ECR = 3×10^{-4}.
Future Use: On-Site Worker	Total HI = 20. This HI is driven by ingestion of Gallia groundwater containing arsenic. Incremental HI = 20.	Total ECR = 4×10^{-3}. This ECR is driven by exposure to Gallia groundwater containing arsenic and beryllium. Risks in excess of 10^{-6} are also presented by exposure to PAHs in soil (3×10^{-4}) and external radiation exposure associated with uranium levels in soil (2×10^{-6}). Incremental ECR = 4×10^{-3}.
Future Use: On-Site Resident	Total HI = 50. This HI is driven by ingestion of Gallia groundwater containing arsenic. The following also present HIs greater than one: recreational exposure (4) and exposure to chromium in Gallia groundwater (1). Incremental HI = 50.	Total ECR $> 10^{-2}$. This ECR is driven by exposure to Gallia groundwater containing arsenic. The following also present ECRs in excess of 10^{-6}: beef and milk ingestion (3×10^{-4}); recreational exposure (3×10^{-4}); exposure to beryllium in Gallia groundwater (4×10^{-4}), exposure to PAHs in soil (1×10^{-3}), and external radiation (specifically uranium) (2×10^{-6}). Incremental ECR $> 10^{-2}$.

Summary of Risks Associated with SWMU: X-230J3 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Excavation Worker	Total HI = 60. This HI is driven by inhalation of nitrobenzene vapors from soil, based on modeled air concentrations under excavation conditions. Incremental HI = 60.	Total ECR = 2×10^{-5}. This ECR is driven by exposure to PAHs in soil. Inhalation of benzene vapors from soil, based on modeled concentrations under excavation conditions, also presents an ECR of 1×10^{-6}. Incremental ECR = 1×10^{-5}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-230J3 unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.189. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 3, and the excess cancer risk is 6×10^{-4}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 10, and the excess cancer risk is 2×10^{-3}. The noncancer HI for both populations is largely attributable to arsenic; the excess cancer risk is also largely attributable to arsenic.

6.5.3.4.2 X-230J5 West Holding Pond and Oil Separation Basin

The X-230J5 West Holding Pond is a 1.7-acre facility used to control sedimentation resulting from storm-water runoff. The pond receives discharge from storm sewers that drain the northwestern portion of the plant site and cooling water from the process-area air

conditioning system. An oil-skimming boom directs waste or process oil and water to a secondary oil-collection basin located adjacent to the pond. Under normal discharge conditions, the amount of recoverable waste oil is insignificant. The disposal of hazardous materials or constituents is not permitted at the unit.

Summary risk estimates for the X-230J5 unit based on constituents present in soil samples collected near the holding pond are presented in Tables 6.190 to 6.193 and are discussed below.

Summary of Risks Associated with SWMU: X-230J5 (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 2×10^{-5}. Incremental HI = 2×10^{-5}.	Total ECR: Not calculated. None of the constituents detected in shallow soil from the X-230J5 unit at levels above background are considered by U.S. EPA to be potential carcinogens. Incremental ECR: Not calculated.
Future Use: On-Site Worker	Total HI = 5×10^{-2}. Incremental HI = 5×10^{-2}.	Total ECR = 1×10^{-4}. This ECR is driven by exposure to PAHs and Aroclor-1260 in soil. Incremental ECR = 1×10^{-4}.
Future Use: On-Site Resident	Total HI = 4. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 2×10^{-1}. Incremental HI = 4.	Total ECR = 9×10^{-4}. This ECR is driven by exposure to PAHs in soil, beef and milk ingestion and recreational exposure. The following also present ECRs in excess of 10^{-6}: exposure to PCBs (Aroclor-1260) in the soil of this SWMU (6×10^{-6}) and external radiation (specifically uranium) (1×10^{-6}). The ECR without the quadrant-wide and recreational risk is 3×10^{-4}. Incremental ECR = 9×10^{-4}.

Summary of Risks Associated with SWMU: X-230J5 (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Excavation Worker	Total HI = 2×10^{-1}. Incremental HI = 2×10^{-1}.	Total ECR = 4×10^{-6}. This ECR is driven by exposure to PAHs in soil. Incremental ECR = 4×10^{-6}.

Summary risk estimates for the X-230J5 unit associated with sediment samples taken from the holding pond and containment basin are presented in Tables 6.194 and 6.195 and are discussed below. For assessing potential risks associated with sediments and surface water, a current on-site worker scenario and future on-site recreational scenario were assumed. The worker risk estimates associated with sediment have been calculated separately from risk estimates associated with soil because the assessments of both media are based on exposure of the worker for 5 days/week, 50 weeks/year, for 25 years under RME conditions. The two sets of RME worker exposures are therefore not additive.

Summary of Risks Associated with SWMU: X-230J5 (Sediment)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 6×10^{-1}. Incremental HI = 6×10^{-1}.	Total ECR = 8×10^{-5}. This ECR is driven by exposure to PAHs and arsenic in sediment. Risks in excess of 10^{-6} are also presented by beryllium (2×10^{-6}) and Aroclor-1260 (2×10^{-6}) in sediment. Incremental ECR = 8×10^{-5}.

Summary of Risks Associated with SWMU: X-230J5 (Sediment)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Recreational Population	Total HI = 9×10^{-1}. Incremental HI = 9×10^{-1}.	Total ECR = 2×10^{-4}. This ECR is driven by exposure to PAHs and arsenic in sediment. Risks in excess of 10^{-6} are also presented by beryllium (5×10^{-6}) and Aroclor-1260 (4×10^{-6}) in sediment. Incremental ECR = 2×10^{-4}.

As stated above, total potential risk to the on-site worker associated with combined exposure to soil and sediment was not estimated. See Section 6.5.4.1 for a discussion of uncertainties associated with assessment of exposure to multiple media in a given SWMU.

6.5.3.4.3 X-326 Process Building

The X-326 Process Building houses the facilities for the final phase of the U-235 enrichment process. The building is 2,230 feet long, 552 feet wide, 62 feet high and contains 58 acres of floor space. The building contains 2,340 diffusion cascade stages that are used to enrich the U-235 stream and 60 purge stages that separate the light-gas contaminants (air, N_2, HF and Freon-114 coolant) from the U-235 stream. Purge gases are passed through alumina traps during the purging process to catch escaping UF_6. The residue from this recovery processing is currently stored in the X-744G warehouse.

Summary risk estimates for the X-326 unit by exposure scenario are presented in Tables 6.196 to 6.200 and are discussed below. Estimated risks associated with this unit are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: X-326 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI: Not calculated. Shallow soil samples (0-2 ft) at the X-326 unit were analyzed for chromium and zinc only. Neither of these inorganic compounds was present at levels above tentative background. Incremental HI: Not calculated.	Total ECR: Not calculated. Shallow soil samples (0-2 ft) at the X-326 unit were analyzed for chromium and zinc only. Neither of these inorganic compounds was present at levels above tentative background. Incremental ECR: Not calculated.
Future Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 2×10^{-1}.	Total ECR = 2×10^{-5}. This excess cancer risk is driven by exposure to chloroform via ingestion in drinking water and inhalation during showering. Incremental ECR = 2×10^{-5}.
Future Use: On-Site Resident	Total HI = 5. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 7×10^{-1}. Incremental HI = 5.	Total ECR = 6×10^{-4}. This ECR is driven by beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk is 3×10^{-5} and is driven by exposure to chloroform in groundwater from the Gallia aquifer. Incremental ECR = 6×10^{-4}.
Excavation Worker	Total HI: Not calculated. Deep soil samples (0-10 ft) at the X-326 unit were analyzed for chromium and zinc only. Neither of these inorganic compounds was present at levels above tentative background. Incremental HI: Not calculated.	Total ECR: Not calculated. Deep soil samples (0-10 ft) at the X-326 unit were analyzed for chromium and zinc only. Neither of these inorganic compounds was present at levels above tentative background. Incremental ECR: Not calculated.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-326 unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.200. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 9, and the excess cancer risk is 2×10^{-3}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 30, and the excess cancer risk is 6×10^{-3}. The noncancer HI for both populations is largely attributable to arsenic; the excess cancer risk is also largely attributable to arsenic.

6.5.3.4.4 X-330 Process Building

The X-330 Process Building houses the facilities for the intermediate phase of the U-235 enrichment process. The building is 2,176 feet long, 640 feet wide, 66 feet high and contains 55 acres of floor space. The building contains 1,100 diffusion cascade stages that are used to enrich the U-235 stream. The enriched stream of U-235 is injected into the X-326 Process Building for further concentration while a depleted stream, or "tails," of U-238 is withdrawn at the tails withdrawal facility located in the northeast corner of the building.

Summary risk estimates for the X-330 unit by exposure scenario are presented in Tables 6.201 to 6.205 and are discussed below. Estimated risks associated with this unit are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: X-330 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI: Not calculated. Shallow soil samples (0-2 ft) at the X-330 unit were analyzed for chromium and zinc only. Neither of these inorganic compounds was present at levels above tentative background. Incremental HI: Not calculated.	Total ECR: Not calculated. Shallow soil samples (0-2 ft) at the X-330 unit were analyzed for chromium and zinc only. Neither of these inorganic compounds was present at levels above tentative background. Incremental ECR: Not calculated.
Future Use: On-Site Worker	Total HI = 2. This HI value is driven by exposure to arsenic in groundwater from the Gallia aquifer via drinking water ingestion. Incremental HI = 2.	Total ECR = 4×10^{-4}. This ECR is driven by exposure to arsenic in groundwater from the Gallia aquifer via drinking water ingestion. Incremental ECR = 4×10^{-4}.
Future Use: On-Site Resident	Total HI = 10. This HI is driven by exposure to arsenic in groundwater from the Gallia aquifer and recreational exposure. The HI without the quadrant-wide and recreational risk is 6. Incremental HI = 10.	Total ECR = 2×10^{-3}. This ECR is driven by exposure to arsenic in groundwater from the Gallia aquifer. The following also present ECRs in excess of 10^{-6}: beef and milk ingestion (3×10^{-4}) and recreational exposure (3×10^{-4}). The ECR without the quadrant-wide and recreational risk is 1×10^{-3}. Incremental ECR = 2×10^{-3}.
Excavation Worker	Total HI = 1×10^{-6}. Incremental HI = 1×10^{-6}.	Total ECR = 5×10^{-7}. Incremental ECR = 5×10^{-7}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all

media for the X-330 unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.205. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 1, and the excess cancer risk is 3×10^{-4}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 3, and the excess cancer risk is 1×10^{-3}. The noncancer HI for both populations is largely attributable to arsenic; the excess cancer risk is largely attributable to arsenic and beryllium.

6.5.3.4.5 X-530A Switchyard including X-530B Switch House; X-530C Test and Repair Building; X-530D Oil House; X-530E Valve House; X-530F Valve House; X-530G GCEP Oil Pumping Station

The X-530A Switchyard contains electrical transformers and circuit breakers, some of which contain PCB oil. The bed of the switchyard is composed of 1 to 3 feet of coarse limestone gravel underlain by clay soil into which are cut a series of French drains in a north-south orientation. The drains discharge into the A and B storm sewers and the northern tributaries of the West Drainage Ditch. The switchyard has stored within it 647,601 gallons of PCB-based transformer oil (Askarel) in various transformers, circuit breakers and tanks. Over the switchyard's period of operation since the 1950s, transformer oil containing PCBs has been accidently released to the limestone-gravel bed. During precipitation events, this oil is leached from the switchyard into the west storm-drainage system. The X-530B Switchyard Houses enclose six transformers, each associated with a synchronous condenser containing 25 gallons of PCB. The condensers are in a diked basin with sumps.

Summary risk estimates for the X-530A unit by exposure scenario are presented in Tables 6.206 to 6.210 and are discussed below. Estimated risks associated with this unit are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: X-530A (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 7×10^{-2}. Incremental HI = 4×10^{-2}.	Total ECR = 3×10^{-5}. This ECR is driven by exposure to Aroclor-1260 and PAHs in soil. Incremental ECR = 3×10^{-5}.
Future Use: On-Site Worker	Total HI = 2. This HI value is driven by exposure to arsenic in groundwater from the Gallia aquifer via drinking water ingestion. Incremental HI = 2.	Total ECR = 4×10^{-4}. This ECR is driven by exposure to arsenic in groundwater from the Gallia aquifer via drinking water ingestion. Risks in excess of 10^{-6} are also presented by exposure to PAHs (2×10^{-5}) and PCBs (4×10^{-6}) in soil. Incremental ECR = 4×10^{-4}.
Future Use: On-Site Resident	Total HI = 10. This HI is driven by exposure to arsenic in groundwater from the Gallia aquifer. Recreational exposure also presents an HI of 4. The HI without the quadrant-wide and recreational risk is 6. Incremental HI = 10.	Total ECR = 2×10^{-3}. This ECR is driven by exposure to arsenic in groundwater from the Gallia aquifer. The following also present ECRs in excess of 10^{-6}: beef and milk ingestion (3×10^{-4}); recreational exposure (3×10^{-4}); exposure to PAHs (7×10^{-5}) and PCBs (1×10^{-5}) in the soil of this SWMU; and exposure to trichloroethene in groundwater (4×10^{-6}). The ECR without the quadrant-wide and recreational risk is 1×10^{-3}. Incremental ECR = 2×10^{-3}.

Summary of Risks Associated with SWMU: X-530A (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Excavation Worker	Total HI = 1. This HI is attributable to inhalation of chlorinated hydrocarbon vapors from soil, based on modeled air concentrations under excavation conditions. None of the individual constituents, however, presents an HQ greater than one. Incremental HI = 1.	Total ECR = 3×10^{-6}. This ECR is driven by inhalation of chlorinated hydrocarbon vapors (in particular, 1,1-dichloroethene) from soil, based on modeled air concentrations under excavation conditions. Incremental ECR = 3×10^{-6}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-530A unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.210. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 4, and the excess cancer risk is 8×10^{-4}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 10, and the excess cancer risk is 3×10^{-3}. The noncancer HI for both populations is largely attributable to arsenic; the excess cancer risk is also largely attributable to arsenic.

6.5.3.4.6 X-615 Abandoned Sanitary Sewage Treatment Facility

The X-615 Abandoned Sanitary Sewage Treatment Facility was deactivated in 1982 after the construction of the new X-6619 facility. Prior to this, nearly all plant-site sanitary sewage was treated at the X-615 facility. Effluent was piped to the Scioto River via an underground pipeline, and sewage sludge was landfarmed on the plant's oil-biodegradation plots. Following deactivation of the X-615 facility in 1982, analysis of digester and drying bed materials and underlying soil showed detectable levels of uranium, PCBs, 2,4-D and 2,4,5-TP (Silvex). The contaminated materials were removed and containerized and are currently stored in the X-330 and X-333 process buildings.

Summary risk estimates for the X-615 unit by exposure scenario are presented in Tables 6.211 to 6.214 and are discussed below. Estimated risks associated with this unit are based on data for soil.

Summary of Risks Associated with SWMU: X-615 (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 1×10^{-1}.	Total ECR = 7×10^{-5}. This ECR is driven by exposure to soil containing Aroclor-1260 and beryllium. Incremental ECR = 6×10^{-5}.
Future Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 1×10^{-1}.	Total ECR = 7×10^{-5}. This ECR is driven by exposure to soil containing Aroclor-1260 and beryllium. Incremental ECR = 6×10^{-5}.

Summary of Risks Associated with SWMU: X-615 (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Resident	Total HI = 5. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 7 x 10^{-1}. Incremental HI = 4.	Total ECR = 8 x 10^{-4}. This ECR is driven by exposure to Aroclor-1260 and beryllium in soil, beef and milk ingestion, and recreational exposure. Risks in excess of 10^{-6} are also presented by PAHs in soil (2 x 10^{-6}) and by external radiation exposure associated with uranium levels in soil (1 x 10^{-6}). The ECR without the quadrant-wide and recreational risk is 2 x 10^{-4}. Incremental ECR = 7 x 10^{-4}.
Excavation Worker	Total HI = 4 x 10^{-1}. Incremental HI = 3 x 10^{-1}.	Total ECR = 5 x 10^{-6}. This ECR is driven by exposure to beryllium in soil and to soil vapors of benzene. Benzene risks are based on modeled air concentrations under excavation conditions. Incremental ECR = 4 x 10^{-6}.

6.5.3.4.7 X-616 Liquid Effluent Control Facility/Former Chromium Sludge Lagoons

The X-616 Liquid Effluent Control Facility processed RCW blowdown. Until 1989, a chromium-based corrosion inhibitor was used; the chromium in the blowdown was precipitated in a clarifier by adjusting pH with slaked lime and polymer coagulant. This process resulted in the formation of a lime sludge containing trivalent chromium. The settled precipitate was transferred to the South Lagoon. Approximately 700,000 kg of dried trivalent chromium sludge was stored at the X-616 facility.

In early 1990, the dried chromium sludge that was stored at X-616 was placed in containers and moved to a storage facility located in another part of the plant. In the fall of 1990, closure of the lagoons commenced. After all of the sludge and contaminated soil was removed from the lagoons, the soil from the lagoon berms was used to fill in the lagoons. Additional fill materials were used to bring this area to grade, and the area was seeded in order to provide a vegetative cover.

Summary risk estimates for the X-616 unit by exposure scenario are presented in Tables 6.215 to 6.217 and are discussed below. Estimated risks associated with this unit are based on data for groundwater.

Summary of Risks Associated with SWMU: X-616 (Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Only groundwater samples from this unit were taken and analyzed. Because there is no current exposure of on-site workers to groundwater, potential risks under the current worker scenario have not been assessed.	
Future Use: On-Site Worker	Total HI = 4×10^{-2}. Incremental HI = 4×10^{-2}.	Total ECR = 8×10^{-5}. This ECR is driven by exposure to groundwater from the Gallia aquifer containing 1,1-dichloroethene. Incremental ECR = 8×10^{-5}.
Future Use: On-Site Resident	Total HI = 4. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 1×10^{-1}. Incremental HI = 4.	Total ECR = 8×10^{-4}. This ECR is driven by exposure to chlorinated hydrocarbons (specifically, 1,1-dichloroethene and trichloroethene) in groundwater from the Gallia aquifer, beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk is 2×10^{-4}. Incremental ECR = 8×10^{-4}.
Excavation Worker	Only groundwater samples from this unit were taken and analyzed. Because exposure to soil only is assumed under the excavation scenario, potential risks for the excavation worker have not been assessed.	

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-616 unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.217. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 3×10^{-3}, and the excess cancer risk is 6×10^{-6}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 8×10^{-3}, and the excess cancer risk is 2×10^{-5}. The excess cancer risks for both populations are largely attributable to chlorinated hydrocarbons, and in particular 1,1-dichloroethene and trichloroethene.

6.5.3.4.8 X-740 Waste Oil Handling Facility

The X-740 Waste Oil Handling Facility consists of a diked concrete pad with a roof and plastic-sheet windbreaks to protect the interior from weather. A concrete temporary drum storage pad, which is stained with oil, is located approximately 200 feet to the northeast of the facility. The facility was used as a staging area for waste oils and solvent pending analysis of drum contents and consequent final disposition. Empty drums were crushed at the X-740 facility and subsequently disposed of at the X-735 landfill.

Summary risk estimates for the X-740 unit by exposure scenario are presented in Tables 6.218 to 6.222 and are discussed below. Estimated risks associated with this unit are based on Phase I data for soil and groundwater.

Summary of Risks Associated with SWMU: X-740 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 1×10^{-1}.	Total ECR = 3×10^{-5}. This ECR is driven by exposure to soil containing arsenic. Incremental ECR = 1×10^{-5}.
Future Use: On-Site Worker	Total HI = 4. This HI value is driven by exposure to 1,1-dichloroethene and arsenic in groundwater from the Gallia aquifer. Incremental HI = 4.	Total ECR = 5×10^{-3}. This ECR is driven by exposure to chlorinated hydrocarbons (in particular 1,1-dichloroethene, tetrachloroethene, and trichloroethene) and arsenic in groundwater from the Gallia aquifer. Risks in excess of 10^{-6} are also presented by arsenic (2×10^{-5}) in soil from this unit. Incremental ECR = 5×10^{-3}.
Future Use: On-Site Resident	Total HI = 20. This HI is driven by exposure to chlorinated hydrocarbons (and in particular 1,1-dichloroethene) and arsenic in groundwater from the Gallia aquifer. Recreational exposure also presents an HI of 4. The HI without the quadrant-wide and recreational risk is 10. Incremental HI = 20.	Total ECR > 10^{-2}. This ECR is driven by exposure to chlorinated hydrocarbons (in particular 1,1-dichloroethene, tetrachloroethene, 1,1,2-trichloroethane, and trichloroethene) and arsenic in groundwater from the Gallia aquifer. The following also present ECRs in excess of 10^{-6}: beef and milk ingestion (3×10^{-4}); recreational exposure (3×10^{-4}); and arsenic (2×10^{-4}) and PAHs (2×10^{-6}) in the soil of the SWMU. Incremental ECR > 10^{-2}.
Excavation Worker	Total HI = 1. This HI is driven by exposure to arsenic in soil. None of the individual pathways, however, presents an HI greater than one. Incremental HI = 6×10^{-1}.	Total ECR = 4×10^{-6}. This ECR is driven by exposure to inorganic constituents, especially arsenic, in soil. Incremental ECR = 2×10^{-6}.

Phase I data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-740 unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.222. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 1×10^{-1}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 4×10^{-1}. The excess cancer risk under these scenarios was not calculated because none of the detected chemicals is considered carcinogenic by U.S. EPA.

Screening Level Assessment for X-740 Phase II Data

Since the quantitative risk assessment was conducted for the X-740 unit, additional Phase II soil and groundwater data were collected. Potential health risks associated with chemicals detected in the Phase II data sets were evaluated using a screening level methodology to determine whether their inclusion in the risk assesssment for the X-740 unit would significantly influence the outcome of the assessment. The screening level analysis was accomplished by undertaking the following comparisons:

- Comparison of the maximum detected concentrations in the Phase II data set with the RME concentrations calculated using the Phase I data.

  Because the maximum detected concentration was used to represent the RME exposure concentration in the quantitative risk assessment for individual SWMUs, the additional Phase II X-740 data would influence exposure concentrations and

risk estimates only if the maximum detected concentration from the Phase II data set was greater than the maximum detected concentration in the Phase I data set. Where a chemical present in the Phase II data set was not detected in the Phase I investigation, the following comparison was performed.

- Comparison of the maximum detected concentration in the Phase II data set with the appropriate risk based Remedial Action Objective (RAO).

  RAOs used in this screen are chemical-specific concentrations that correspond to a noncancer hazard index (HI) of one or an excess cancer risk level of 10^{-6} under the assumptions developed in this BRA for a future on-site resident. The derivation of risk-based RAOs is described more fully in Section 6.7.

The results of the screening level assessment were as follows:

Soil. PAHs and Aroclor 1254 and 1260 at levels present in Phase II soil samples were associated with the largest potential risks, with risks under the future residential scenario estimated to be approximately 10^{-5}. Estimated risks associated with soil constituents detected during the Phase I investigation were approximately 10^{-4} (see above).

Gallia groundwater. Analysis of Phase I data (see above) revealed that excess cancer risks associated with chlorinated hydrocarbons in groundwater from the Gallia aquifer were estimated to be greater than 10^{-2} and well above the range generally considered acceptable by U.S. EPA. Therefore, the detections in the Phase II groundwater data set do not significantly influence the risk assessment conclusions for the Gallia aquifer.

Berea groundwater. Analysis of Phase I data (see above) revealed that potential risks associated with constituents in groundwater from this aquifer were insignificant; the hazard index was less than one and no carcinogenic chemicals were detected in groundwater. The maximum detections of chlorinated hydrocarbons (in particular 1,2-dichloroethane, 1,1-dichloroethene, tetrachloroethene, and trichloroethene) in Berea groundwater from the Phase II sampling were estimated to result in potential excess cancer risks of approximately 10^{-3}.

6.5.3.4.9 X-744N, X-744P, X-744Q Warehouse and Associated Oil Construction Headquarters Area

During construction of the PORTS facility in the early 1950s, the area not occupied by X-744N, X-744P, and X-744Q was used by Peter Kiewit contractors as a headquarters and parking area. Lithium hydroxide is currently being stored in the X-744N, P, and Q warehouses. During construction of the Gas Centrifuge Enrichment Plant, the area adjacent to X-744N, X-744P, and X-744Q was used for borrow and fill; a considerable amount of construction debris was discarded in this area. In the early 1980s, dewatered sludge from the X-2230N West Holding Pond and the X-2230M Southwest Holding Pond was spread south of the X-744N, P, and Q warehouses.

Summary risk estimates for the X-744N unit by exposure scenario are presented in Tables 6.223 to 6.227 and are discussed below. Estimated risks associated with this unit are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: X-744N (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 8×10^{-4}. Incremental HI = 5×10^{-4}.	Total ECR = 2×10^{-6}. This ECR is driven by exposure to benzo(a)pyrene in soil, primarily via dermal absorption from soil. Incremental ECR = 2×10^{-6}.
Future Use: On-Site Worker	Total HI = 1. This HI is attributable to exposure to several inorganic constituents in groundwater from the Gallia aquifer. None of the individual contituents, however, presents an HQ greater than one. Incremental HI = 1.	Total ECR = 2×10^{-5}. This ECR is driven by exposure to arsenic in soil. Risks in excess of 10^{-6} are also presented by benzo(a)pyrene in soil associated with dermal exposure (1×10^{-6}). Incremental ECR = 9×10^{-6}.
Future Use: On-Site Resident	Total HI = 8. This HI is driven by exposure to inorganic constituents, especially vanadium, in groundwater from the Gallia aquifer, and by recreational exposure. The HI without the quadrant-wide and recreational risk is 4. Incremental HI = 7.	Total ECR = 7×10^{-4}. This ECR is driven by exposure to arsenic in soil, beef and milk ingestion, and recreational exposure. PAHs in soil also present an ECR of 4×10^{-6}. The ECR without the quadrant-wide and recreational risk is 1×10^{-4}. Incremental ECR = 6×10^{-4}.
Excavation Worker	Total HI = 7×10^{-1}. Incremental HI = 5×10^{-2}.	Total ECR = 3×10^{-6}. This ECR is driven by exposure to arsenic in soil. Incremental ECR = 1×10^{-6}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-744N unit was based on concentrations of constituents in the Gallia

aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.227. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 4, and the excess cancer risk is 5×10^{-4}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 10, and the excess cancer risk is 2×10^{-3}. The noncancer HI for both populations is largely attributable to antimony and arsenic; the excess cancer risk is largely attributable to arsenic.

6.5.3.4.10 X-744S, X-744T, X-744U Lithium Storage Warehouses

Approximately 80,000 cubic yards of lithium hydroxide is stored in the X-744S, T, and U warehouses. It was reported in 1984 that the crystalline lithium hydroxide was stored in cardboard drums, allowing contact with precipitation. An unknown quantity of paint thinner was discarded onto the ground at the southwest corner of the X-744T building in 1989.

Summary risk estimates for the X-744S unit by exposure scenario are presented in Tables 6.228 to 6.231 and are discussed below. Estimated risks associated with this unit are based on data for soil.

Summary of Risks Associated with SWMU: X-744S (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 8×10^{-3}. Incremental HI = 7×10^{-3}.	Total ECR = 2×10^{-6}. This ECR is driven by exposure to Aroclor-1260 and PAHs in soil. None of the individual constituents, however, presents an ECR greater than 10^{-6}. Incremental ECR = 2×10^{-6}.
Future Use: On-Site Worker	Total HI = 8×10^{-3}. Incremental HI = 7×10^{-3}.	Total ECR = 2×10^{-6}. This ECR is driven by exposure to Aroclor-1260 and PAHs in soil. None of the individual constituents, however, presents an ECR greater than 10^{-6}. Incremental ECR = 2×10^{-6}.
Future Use: On-Site Resident	Total HI = 4. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 9×10^{-2}. Incremental HI = 4.	Total ECR = 6×10^{-4}. This ECR is driven by beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk is 8×10^{-6} and is driven by exposure to Aroclor-1260 and PAHs in the soil of this SWMU. Incremental ECR = 6×10^{-4}.
Excavation Worker	Total HI = 1×10^{-1}. Incremental HI = 1×10^{-1}.	Total ECR = 4×10^{-6}. This ECR is driven by inhalation of soil vapors of several chlorinated hydrocarbon, based on modeled air concentrations. Incremental ECR = 4×10^{-6}.

6.5.3.4.11 X-745C West Cylinder Storage Yard

UF_6 that is sufficiently depleted in U-235 to make further processing uneconomical is permanently stored in 14-ton cylinders at the X-745C West Cylinder Storage Yard. The west portion of the yard is surfaced with concrete.

Summary risk estimates for the X-745C unit by exposure scenario are presented in Tables 6.232 to 6.235 and are discussed below. Estimated risks associated with this unit are based on data for soil.

Summary of Risks Associated with SWMU: X-745C (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 9×10^{-2}.	Total ECR = 6×10^{-5}. This ECR is driven by exposure to Aroclors-1254 and 1260, PAHs, arsenic, and beryllium in soil from this unit. Incremental ECR = 4×10^{-5}.
Future Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 9×10^{-2}.	Total ECR = 6×10^{-5}. This ECR is driven by exposure to Aroclors-1254 and 1260, PAHs, arsenic, and beryllium in soil from this unit. Incremental ECR = 4×10^{-5}.

Summary of Risks Associated with SWMU: X-745C (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Resident	Total HI = 5. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 6×10^{-1}. Incremental HI = 4.	Total ECR = 8×10^{-4}. This ECR is driven by exposure to arsenic in soil, beef and milk ingestion, and recreational exposure. The following also present ECRs in excess of 10^{-6}: PAHs (6×10^{-5}), beryllium (7×10^{-5}), and PCBs (2×10^{-5}) in the soil of this SWMU. The ECR without the quadrant-wide and recreational risk is 2×10^{-4}. Incremental ECR = 7×10^{-4}.
Excavation Worker	Total HI = 7×10^{-1}. Incremental HI = 2×10^{-1}.	Total ECR = 5×10^{-6}. This ECR is driven by exposure to arsenic in soil. Incremental ECR = 3×10^{-6}.

6.5.3.4.12 X-2230N West Holding Pond No. 2

The X-2230N West Holding Pond No. 2 was constructed in 1978 to control erosion and sediment transport in storm-water runoff from the northern half of the former Gas Centrifuge Enrichment Plant (GCEP) construction site via the West Drainage Ditch. Part of the flow results from once-through cooling water coming from air-conditioning systems. The X-2230N pond discharges to a southern branch of the West Drainage Ditch, which then discharges to the Scioto River approximately two miles west of PORTS. The pond effluent is regulated by an NPDES permit. The pond was dredged in the early 1980s due to rapid accumulation of silt from runoff during GCEP construction activities.

Summary risk estimates for the X-2230N holding pond based on constituents present in soil samples collected from areas adjacent to the holding pond are presented in Table 6.236 to 6.239 and are discussed below.

Summary of Risks Associated with SWMU: X-2230N (Soil)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 1×10^{-3}. Incremental HI = 7×10^{-4}.	Total ECR = 1×10^{-7}. Incremental ECR = 1×10^{-7}.
Future Use: On-Site Worker	Total HI = 4×10^{-2}. Incremental HI = 2×10^{-2}.	Total ECR = 1×10^{-7}. Incremental ECR = 1×10^{-7}.
Future Use: On-Site Resident	Total HI = 4. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 2×10^{-1}. Incremental HI = 4.	Total ECR = 6×10^{-4}. This ECR is driven by beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk is 1×10^{-6} and is largely attributable to ingestion of technetium in vegetables. None of the individual pathways, however, presents an ECR in excess of 10^{-6}. Incremental ECR = 6×10^{-4}.
Excavation Worker	Total HI = 3×10^{-2}. Incremental HI = 2×10^{-2}.	Total ECR = 1×10^{-6}. This ECR is driven by inhalation of soil particulates containing chromium. Incremental ECR = 5×10^{-7}.

Summary risk estimates for the X-2230N unit associated with sediment and surface water samples taken from the holding pond are presented in Tables 6.240 and 6.241 and are discussed below. For assessing potential risks associated with sediments and surface water, a current on-site worker scenario and future on-site recreational scenario were

assumed. The worker risk estimates associated with sediment and surface water have been calculated separately from risk estimates associated with soil because the assessments of both media are based on exposure of the worker for 5 days/week, 50 weeks/year, for 25 years under RME conditions. The two sets of RME worker exposures are therefore not additive.

Summary of Risks Associated with SWMU: X-2230N (Sediment and Surface Water)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 4×10^{-1}. Incremental HI = 4×10^{-1}.	Total ECR = 1×10^{-5}. This ECR is driven by exposure to Aroclor-1260, arsenic, and beryllium in sediment. Incremental ECR = 1×10^{-5}.
Future Use: On-Site Recreational Population	Total HI = 5×10^{-1}. Incremental HI = 5×10^{-1}.	Total ECR = 3×10^{-5}. This ECR is driven by exposure to Aroclor-1260, arsenic, and beryllium in sediment. Incremental ECR = 3×10^{-5}.

As stated above, total potential risk to the on-site worker associated with combined exposure to soil, surface water, and sediment was not estimated. See Section 6.5.4.1 for a discussion of uncertainties associated with assessment of exposure to multiple media in a given SWMU.

6.5.3.4.13 X-6619 and X-6614E Sewage Treatment Facility

The X-6619 Sewage Treatment Plant, which uses an activated sludge treatment process, became operational in 1981. Raw sewage treated at the facility is collected from

all areas of the plant site. Effluent is discharged to the Scioto River via an underground pipe. The effluent is monitored under an NPDES permit. Hazardous materials are not permitted to be processed through the sewage treatment plant; however, radiological constituents, mercury, and PCBs have been detected in sludge from the plant.

Summary risk estimates for the X-6619 unit by exposure scenario are presented in Tables 6.242 to 6.246 and are discussed below. Estimated risks associated with this unit are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: X-6619 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 7×10^{-2}. Incremental HI = 5×10^{-3}.	Total ECR = 1×10^{-5}. This ECR is driven by exposure to arsenic in soil from this unit. Incremental ECR = 1×10^{-6}.
Future Use: On-Site Worker	Total HI = 7×10^{-1}. Incremental HI = 6×10^{-1}.	Total ECR = 9×10^{-5}. This ECR is driven by exposure to arsenic in both soil and groundwater from this unit. Incremental ECR = 8×10^{-5}.
Future Use: On-Site Resident	Total HI = 6. This HI is driven by exposure to arsenic in the groundwater of the Gallia aquifer and by recreational exposure. The HI without the quadrant-wide and recreational risk is 2. Incremental HI = 6.	Total ECR = 9×10^{-4}. This ECR is driven by exposure to arsenic in the groundwater of the Gallia aquifer, beef and milk ingestion, and recreational exposure. Arsenic in the soil of this SWMU also presents an ECR of 9×10^{-5}. The ECR without the quadrant-wide and recreational risk is 4×10^{-4}. Incremental ECR = 8×10^{-4}.

Summary of Risks Associated with SWMU: X-6619 (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Excavation Worker	Total HI = 4×10^{-1}. Incremental HI = 3×10^{-2}.	Total ECR = 2×10^{-6}. This ECR is driven by exposure to arsenic in soil. Incremental ECR = 1×10^{-7}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the X-6619 unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.246. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 2, and the excess cancer risk is 3×10^{-4}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 5, and the excess cancer risk is 1×10^{-3}. The noncancer HI for both populations is largely attributable to arsenic; the excess cancer risk is also largely attributable to arsenic.

6.5.3.4.14 X-7725 Recycle Assembly Building, X-7745R Recycle/Assembly Storage Yard, and Initial Construction Bulk Fuel Storage Area (BFS)

The X-7725 Recycle/Assembly Building is a Gaseous Centrifuge Enrichment Plant (GCEP) support facility where new centrifuges, used in the U-235 enrichment process, were assembled and where failed centrifuges were rebuilt. The building encloses approximately 400,000 square feet. The X-7745R Recycle/Assembly Storage Yard

encloses approximately six acres and functioned as a storage facility for new centrifuge machine casings during operation at GCEP. During construction of the PORTS facility in the mid-1950s, a bulk fuel storage yard, used for storage and dispensing of gasoline and diesel fuel, was located near the southwest corner of the present X-7725 Recycle/Assembly Building.

Summary risk estimates for this unit by exposure scenario are presented in Tables 6.247 to 6.251 and are discussed below. Estimated risks associated with this unit are based on data for soil and groundwater.

Summary of Risks Associated with SWMU: BFS (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 2×10^{-1}. Incremental HI = 7×10^{-2}.	Total ECR = 3×10^{-5}. This ECR is driven by exposure to arsenic in soil from this unit. Incremental ECR = 1×10^{-5}.
Future Use: On-Site Worker	Total HI = 2. This HI is largely attributable to exposure to several inorganic compounds in groundwater (via ingestion) and to several inorganic compounds in soil (via incidental ingestion and dermal contact). None of the individual chemicals or exposure pathways, however, presents an HQ or HI greater than one. Incremental HI = 2.	Total ECR = 3×10^{-4}. This ECR is driven by exposure to arsenic in groundwater from the Gallia aquifer and to arsenic and beryllium in soil from this unit. Incremental ECR = 2×10^{-4}.

Summary of Risks Associated with SWMU: BFS (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Resident	Total HI = 10. This HI is largely attributable to inorganic constituents, especially arsenic in the soil and the Gallia groundwater, and to recreational exposures. The HI without the quadrant-wide and recreational risk is 6. Incremental HI = 9.	Total ECR = 2×10^{-3}. This ECR is driven by exposure to arsenic in groundwater from the Gallia aquifer and arsenic and beryllium in the soil of this SWMU. The following also present ECRs in excess of 10^{-6}: beef and milk ingestion (3×10^{-4}) and recreational exposure (3×10^{-4}). Incremental ECR = 2×10^{-3}.
Excavation Worker	Total HI = 6. This HI is largely attributable to exposure to arsenic in the soil and inhalation of vinyl acetate vapors from the soil. Exposure to soil vapors of vinyl acetate is based on modeled air concentrations. Incremental HI = 5.	Total ECR = 4×10^{-5}. This ECR is driven by exposure to arsenic in the soil and inhalation of heptachlor vapors from the soil. The following also present an ECR in excess of 10^{-6}: inhalation of gamma-chlordane vapors (2×10^{-6}) and soil particulates containing chromium (2×10^{-6}). Exposure to soil vapors and particulates is based on modeled air concentrations. Incremental ECR = 3×10^{-5}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the BFS unit was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.251. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 7×10^{-3}. For the future on-site resident, the HI value associated with exposure to

groundwater from the Berea is 2×10^{-2}. The excess cancer risks under both scenarios were not calculated because none of the detected chemicals is considered carcinogenic by U.S. EPA.

6.5.3.4.15 Don Marquis Substation, Associated Containment Ponds and Drainage Ditches

The Don Marquis substation encloses two tiers of electrical power stations. The smaller, lower tier contains a series of large transformers, each surrounded by secondary containment berms and is drained by three subsurface drains. The larger, upper tier contains a series of large transformers, each of which is surrounded by a secondary containment berm. A drainage ditch is located adjacent to the northwest side. Three small, asphalt-lined containment ponds are located adjacent to the Don Marquis substation. Containment debris is piled in a small area northwest of the upper tier of the substation.

Summary risk estimates for the DMRQ unit associated with soil and groundwater samples are presented in Tables 6.252 to 6.256 and are discussed below.

Summary of Risks Associated with SWMU: DMRQ (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Current Use: On-Site Worker	Total HI = 6×10^{-2}. Incremental HI = 5×10^{-2}.	Total ECR = 2×10^{-7}. Incremental ECR = 2×10^{-7}.

Summary of Risks Associated with SWMU: DMRQ (Soil and Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Worker	Total HI = 7. This HI is driven by exposure to several inorganic compounds in groundwater from the Gallia aquifer. Of these, only arsenic and chromium present HQ values greater than one. Incremental HI = 7.	Total ECR = 1×10^{-3}. This ECR is driven by exposure to arsenic and beryllium in groundwater from the Gallia aquifer. Incremental ECR = 1×10^{-3}.
Future Use: On-Site Resident	Total HI = 20. This HI is driven by exposure to inorganic constituents, especially arsenic, in the groundwater from the Gallia aquifer. Incremental HI = 20.	Total ECR = 4×10^{-3}. This ECR is driven by exposure to arsenic and beryllium in groundwater from the Gallia aquifer. The following also present ECRs in excess of 10^{-6}: beef and milk ingestion (3×10^{-4}) and recreational exposure (3×10^{-4}). Incremental ECR = 4×10^{-3}.
Excavation Worker	Total HI = 2×10^{-1}. Incremental HI = 2×10^{-1}.	Total ECR = 1×10^{-5}. This ECR is driven by exposure to chlorinated hydrocarbon vapors (specifically, chloroform and 1,1-dichloroethene) from the soil. Exposure to soil vapors is based on modeled air concentrations. Incremental ECR = 1×10^{-5}.

Data for the Gallia and Berea aquifers were not combined in the assessments of groundwater. As indicated above, the assessment of total risks from constituents in all media for the Don Marquis Substation was based on concentrations of constituents in the Gallia aquifer. Potential risks associated with exposures of residential and worker populations to groundwater in the Berea aquifer are summarized in Table 6.256. For the future on-site worker, the HI value associated with exposure to groundwater from the Berea

aquifer (via ingestion, dermal contact, and inhalation of volatile organic chemicals while showering) is 5×10^{-1}, and the excess cancer risk is 8×10^{-5}. For the future on-site resident, the HI value associated with exposure to groundwater from the Berea is 1, and the excess cancer risk is 3×10^{-4}. The noncancer HI for both populations is largely attributable to arsenic; the excess cancer risk is also largely attributable to arsenic.

Summary risk estimates for this unit associated with surface water and sediment samples collected from ponds and from the drainage ditch adjacent to the unit are presented in Tables 6.257 and 6.258a and are discussed below. For assessing potential risks associated with sediments and surface water, a current on-site worker scenario and future on-site recreational scenario were assumed. The worker risk estimates for sediment and surface water have been calculated separately from risk estimates associated with soil because the assessments of both media are based on exposure of the worker for 5 days/week, 50 weeks/year, for 25 years under RME conditions. The two sets of RME worker exposures are therefore not additive.

Summary of Risks Associated with SWMU: DMRQ (Sediment and Surface Water)

Exposure Scenario	Noncancer HI	Cancer Risk
Current Use: On-Site Worker	Total HI = 4. This HI is driven by exposure to a number of inorganic compounds in surface water, including arsenic and manganese. With the exception of manganese, none of the inorganic compounds individually presents an HQ greater than one. Incremental HI = 4.	Total ECR = 2×10^{-4}. This ECR is driven by exposure to arsenic and beryllium in surface water. Risks in excess of 10^{-6} are also presented by arsenic (5×10^{-6}) and beryllium (3×10^{-6}) in sediment and by benzo(a)anthracene in surface water (6×10^{-6}). Incremental ECR = 2×10^{-4}.

Summary of Risks Associated with SWMU: DMRQ (Sediment and Surface Water)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Recreational Population	Total HI = 4. This HI is driven by exposure to a number of inorganic compounds in surface water, and in particular manganese. With the exception of manganese, none of the inorganic compounds individually presents an HQ greater than one. Incremental HI = 4.	Total ECR = 1×10^{-4}. This ECR is driven by exposure to arsenic and beryllium in sediments and to benzo(a)anthracene, arsenic, and beryllium in surface water. Incremental ECR = 1×10^{-4}.

As stated above, total potential risk to the on-site worker associated with combined exposure to soil, groundwater, surface water, and sediment was not estimated. See Section 6.5.4.1 for a discussion of uncertainties associated with assessment of exposure to multiple media in a given SWMU.

Screening-Level Assessment for Spring/Summer BERA Data

Since the quantitative risk assessment was conducted for Quadrant III, additional spring/summer BERA data for the Don Marquis Substation were collected. Summaries of soil, sediment, and surface water data from this BERA investigation are presented in Tables 6.258b, 6.258c, and 6.258d, respectively. These data were not included in the above assessment of the DMRQ unit.

Potential health risks associated with chemicals detected in the spring/summer BERA data sets were evaluated using a screening level methodology. Specifically,

maximum concentrations of chemicals in each medium were compared to appropriate risk-based remedial action objectives (RAOs). The RAOs used for this analysis are chemical-specific concentrations that correspond to a noncancer HI of one or an excess cancer risk of 10^{-6} under the assumptions developed in this BRA. The specific scenarios upon which the RAOs were based are:

- future on-site recreational population (sediment and surface water);
- future on-site residential population, with the beef and milk ingestion pathways (soil); or
- future on-site residential population, without the beef and milk ingestion pathways (soil).

The derivation of risk-based RAOs is described more fully in Section 6.7.

In the spring/summer BERA soil data set, five organic and 17 inorganic chemicals were detected. Comparison of measured concentrations for these chemicals to their soil RAOs (Table 6.258b) reveals that RAOs are exceeded by soil concentrations of manganese (three detections). The HQ values associated with the maximum detected concentration of manganese (1,200 mg/kg) are estimated to be 7 (without the beef and milk ingestion pathways) and 14 (with the beef and milk ingestion pathways).

In the spring/summer BERA sediment data set, two organic and 17 inorganic chemicals were detected. Comparison of measured concentrations for these chemicals to their sediment RAOs (Table 6.258c) reveals that RAOs are exceeded by sediment concentrations of arsenic, beryllium, and manganese. The HQ value associated with the single detection of manganese (1,300 mg/kg) is estimated to be two. The excess cancer

risks associated with the single detections of arsenic (6.1 mg/kg) and beryllium (0.93 mg/kg) are estimated to be 5×10^{-6} and 7×10^{-6}, respectively.

In the spring/summer BERA surface water data set, four organic and nine inorganic chemicals were detected. Comparison of measured concentrations for these chemicals to their surface water RAOs (Table 6.258d) reveals that none of the RAOs are exceeded by chemicals present in surface water, indicating that hazard quotients are less than one or excess lifetime cancer risks are less than 10^{-6} for all chemicals in this round of surface water sampling. Thus, surface water detections in this BERA data set present no significant health risk under the assumptions applied in the BRA.

6.5.3.4.16 West Drainage Ditch

The West Drainage Ditch (also known as the Northwest Drainage Ditch) originates from several drainage ditches in the center of Quadrant III that drain the northwestern portion of the plant site. It receives flow from storm sewers A, B, and J, and once-through cooling water from the process area.

Summary risk estimates for the West Drainage Ditch based on constituents present in sediment and surface water are presented in Tables 6.259 to 6.260 and are discussed below. For assessing potential risks associated with sediments and surface water, a current on-site worker scenario and future on-site recreational scenario were assumed.

Summary of Risks Associated with SWMU: WDD (Sediment and Surface Water)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Worker	Total HI = 2. This HI is driven by exposure to manganese in sediment via dermal contact. Incremental HI = 2.	Total ECR = 8×10^{-4}. This ECR is driven by exposure to Aroclor-1260, PAHs, and arsenic in sediment. Risks in excess of 10^{-6} are also presented by beryllium in sediment (6×10^{-6}) and by 1,2-dibromo-3-chloropropane in surface water (6×10^{-6}). Incremental ECR = 8×10^{-4}.
Future Use: On-Site Recreational Population	Total HI = 3. This HI is driven by exposure to manganese in sediment via dermal contact. Incremental HI = 3.	Total ECR = 2×10^{-3}. This ECR is driven by exposure to Aroclor-1260, PAHs, arsenic, and beryllium in sediments. Risks in excess of 10^{-6} are also presented by 1,2-dibromo-3-chloropropane in surface water (1×10^{-5}). Incremental ECR = 2×10^{-3}.

In addition to the assessment of risks associated with constituents in surface water and in sediment samples collected from the West Drainage Ditch, a separate assessment was performed of the potential health risks associated with constituents in leachate samples collected from the seep along the sides of the ditch. Routine current or future exposures to the media in this seep are highly unlikely; however, the conditions under which potential exposure might occur are uncertain. As a preliminary screening level, characterization of potential risk posed by leachate from the seep, exposures under current worker conditions and under the future recreational scenario were conservatively assumed; the assumptions used in the assessment of the seep are the same as those used in the assessment of the ditch itself. The results of this screening level assessment are summarized below and in Tables 6.261 and 6.262. As these tables indicate, the constituents in the seep leachate do not present a significant health risk even under the highly conservative assumption applied here.

See further discussion of uncertainties associated with this screening level analysis in Section 6.5.4.1.

Summary of Risks Associated with SWMU: WDD (Seep)		
Exposure Scenario	**Noncancer IH**	**Cancer Risk**
Seep Assessment/Current Use: On-Site Worker	Total HI = 3×10^{-3}. Incremental HI = 3×10^{-3}.	Total ECR = 9×10^{-8}. Incremental ECR = 9×10^{-8}.
Seep Assessment/Future Use: On-Site Recreational Population	Total HI = 2×10^{-3}. Incremental HI = 2×10^{-3}.	Total ECR = 2×10^{-7}. Incremental ECR = 2×10^{-7}.

As assessment of potential risk associated with constituents in shallow soil samples taken during the fall/winter BERA has also been conducted. These samples were collected adjacent to the drainage ditch downstream of the X-230J5 holding pond. Summary risk estimates for West Drainage Ditch soil samples by scenario are presented in Tables 6.263 to 6.266a and are discussed below.

Summary of Risks Associated with SWMU: WDD (Soil)		
Exposure Scenario	**Noncancer IH**	**Cancer Risk**
Current and Future Use: On-Site Worker	Total HI = 1×10^{-5}. Incremental HI = 1×10^{-5}.	Total ECR: Not calculated. None of the detected chemicals present at levels above background are considered carcinogenic by U.S. EPA. Incremental ECR: Not calculated.

Summary of Risks Associated with SWMU: WDD (Soil)		
Exposure Scenario	**Noncancer IH**	**Cancer Risk**
Future Use: On-Site Resident	Total HI = 4. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 2×10^{-5}. Incremental HI = 4.	Total ECR = 6×10^{-4}. This ECR is driven by beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk was not calculated because none of the detected chemicals in soil from this unit are considered carcinogenic by U.S. EPA. Incremental ECR = 6×10^{-4}.
Excavation Worker	Total HI = 2×10^{-2}. Incremental HI = 2×10^{-2}.	Total ECR: Not calculated. None of the detected chemicals present at levels above background are considered carcinogenic by U.S. EPA. Incremental ECR: Not calculated.

Screening Level Assessment for Spring/Summer BERA Data

Since the quantitative risk assessment was conducted for Quadrant III, additional spring/summer BERA data for the West Drainage Ditch were collected. Summaries of soil, sediment, and surface water data from this BERA investigation are presented in Tables 6.266b, 6.266c and 6.266d, respectively. These data were not included in the above assessment of the ditch.

Potential health risks associated with chemicals detected in the spring/summer BERA data sets were evaluated using a screening level methodology. Specifically, maximum concentrations of chemicals in each medium were compared to appropriate risk-based remedial action objectives (RAOs). The RAOs used for this analysis are chemical-

specific concentrations that correspond to a noncancer HI of one or an excess cancer risk of 10^{-6} under the assumptions developed in this BRA. The specific scenarios upon which the RAOs were based are:

- future on-site recreational population (sediment and surface water);
- future on-site residential population, with the beef and milk ingestion pathways (soil); or
- future on-site residential population, without the beef and milk ingestion pathways (soil).

The derivation of risk-based RAOs is described more fully in Section 6.7.

In the spring/summer BERA soil data set, two organic and 18 inorganic chemicals were detected. Comparison of measured concentrations for these chemicals to their soil RAOs (Table 6.266b) reveals that RAOs are exceeded by soil concentrations of manganese (three detections) and zinc (one detection). The HQ values associated with the maximum detected concentration of manganese (670 mg/kg) are estimated to be 4 and 8 under the on-site residential scenario without and with the beef and milk ingestion pathways, respectively. The HQ value associated with the single detection of zinc (65 mg/kg) is estimated to be 1.

In the spring/summer BERA sediment data set, 13 organic and 19 inorganic chemicals were detected. Comparison of measured concentrations for these chemicals to their sediment RAOs (Table 6.266c) reveals that RAOs are exceeded by sediment concentrations of arsenic (two detections), antimony (one detection), benzo(a)pyrene (two detections), beryllium (one detection), and manganese (one detection). The HQ values associated with the single detections of manganese (920 mg/kg) and antimony

(4,900 mg/kg) are estimated to be 1 and 52, respectively. The excess cancer risks associated with the maximum detected concentrations of arsenic (27 mg/kg), benzo(a)pyrene (240 μg/kg), and beryllium (1.8 mg/kg) are estimated to be 2×10^{-5}, 2×10^{-6}, and 1×10^{-5}, respectively.

In the spring/summer BERA surface water data set, five organic and nine inorganic chemicals were detected. Comparison of measured concentrations for these chemicals to their surface water RAOs (Table 6.266d) reveals that none of the RAOs are exceeded by chemicals present in surface water, indicating that hazard quotients are less than one or excess lifetime cancer risks are less than 10^{-6} for all chemicals in this round of surface water sampling. Thus, surface water detections in this BERA data set present no significant health risk under the assumptions applied in the BRA.

6.5.3.4.17 Groundwater Wells F-31G and F-32B

Wells F-31G (Gallia well) and F-32B (Berea well) are located in the southern portion of Quadrant III east of the X-7721 building. Because these wells are not located in the vicinity of any Quadrant III SWMUs, separate assessments were performed for these two wells.

Summary risk estimates for each well by exposure scenario are presented in Tables 6.267 and 6.268 (Well F-31G) and Tables 6.269 and 6.270a (Well F-32B).

Summary of Risks Associated with Groundwater Well: F-31G (Groundwater)		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Worker	Total HI = 6×10^{-1}. Incremental HI = 6×10^{-1}.	Total ECR: Not calculated. None of the detected chemicals are considered carcinogenic by U.S. EPA. Incremental ECR: Not calculated.
Future Use: On-Site Resident	Total HI = 6. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 2 and is largely attributable to exposure to inorganic constituents in groundwater from the Gallia aquifer. None of the individual constituents, however, presents an HQ greater than one. Further, segregation of HQs by different toxic endpoints suggests that groundwater-related exposures will not produce a non-cancer hazard at this unit (see Section 6.5.4.2). Incremental HI = 6.	Total ECR = 6×10^{-4}. This ECR is driven by beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk was not calculated because none of the detected chemicals are considered carcinogenic by U.S. EPA. Incremental ECR = 6×10^{-4}.

Summary of Risks Associated with SWMU: F-32B		
Exposure Scenario	**Noncancer HI**	**Cancer Risk**
Future Use: On-Site Worker	Total HI = 3×10^{-3}. Incremental HI = 3×10^{-3}.	Total ECR: Not calculated. None of the detected chemicals are considered carcinogenic by U.S. EPA. Incremental ECR: Not calculated.
Future Use: On-Site Resident	Total HI = 4. This HI is driven by recreational exposure. The HI without the quadrant-wide and recreational risk is 8×10^{-3}. Incremental HI = 4.	Total ECR = 6×10^{-4}. This ECR is driven by beef and milk ingestion and recreational exposure. The ECR without the quadrant-wide and recreational risk was not calculated because none of the detected chemicals are considered carcinogenic by U.S. EPA. Incremental ECR = 6×10^{-4}.

6.5.3.5 Potential Risks Associated with Lead

The evaluation of risks associated with exposure to lead is based on the IEUBK model, which predicts blood lead concentrations in children. This model has been applied to the maximum soil lead concentration present in each of the SWMUs for which soil data were available. Because blood lead levels are predicted based on total lead intake, the IEUBK model was run using total lead soil concentrations. This approach differs from that applied to other inorganic chemicals, for which both total and incremental risks were evaluated.

The IEUBK model results based on soil lead levels in each SWMU and the background lead level are presented in Appendix H.6. Even at maximum soil lead concentrations, blood lead levels do not exceed the level generally considered acceptable by U.S. EPA (i.e., a blood lead level of 10 μg/dL or less in 95 percent of exposed

children). Thus, none of the on-site soil lead levels are expected to pose a risk even under the conservative future land use assumption of residential development.

In addition, the IEUBK model was run using the tentative background soil lead concentration (26.2 mg/kg) and the upper and lower end of the range of RME lead concentrations in groundwater (11 and 180 μg/L). At the lower end of this range (11 μg/L), predicted blood lead levels do not exceed the blood lead level generally considered acceptable by U.S. EPA. At the groundwater concentration of 180 μg/L, however, predicted blood lead levels exceed a blood lead level of 10 μg/dL in more than 5 percent of exposed children. Thus, lead concentrations in groundwater from some portions of Quadrant III used as a drinking water source could result in blood lead levels considered unacceptable by U.S. EPA. In the absence of background levels for inorganics in groundwater at the time of this assessment, an analysis of potential risks associated with lead levels in Quadrant III groundwater was not performed for individual SWMUs. Reconsideration of lead levels in groundwater for each SWMU using the approved background values presented in the BSI will be addressed in the CAS/CMS.

6.5.3.6 Potential Risks Associated with Beta-Emitting Radiation

A screen for evaluating dermal exposure to beta-emitting radionuclides will not appear in this report. See Appendix H.2.

6.5.3.7 Potential for Acute Toxicity

An assessment of potential for acute toxicity was performed by comparing One- and Ten-day Drinking Water Health Advisories (U.S. EPA, 1993a) to maximum concentrations of chemicals of potential concern in groundwater and surface water. Drinking Water

Health Advisories are criteria developed by U.S. EPA's Office of Water for the assessment of short-term (one- and ten-day) and longer-term exposure to contaminants in drinking water. One- and Ten-day Health Advisories are one of the few sets of criteria available for evaluating potential health risks associated with short-term, high-level exposures.

Short-term Health Advisories have been developed for 25 of the 53 constituents detected in Quadrant III surface water and groundwater (see Table 6.174). Comparison of the One- and Ten-day Health Advisories to maximum detected levels in surface and groundwater (Table 6.174) shows that the maximum detected concentrations were all below the Health Advisories with the exception of the following:

Summary of Health Advisory Exceedences	
Chemical	**Location of Exceedence**
Groundwater	
1,1-Dichloroethene	X-740 (Gallia)
Antimony	X-744N (Berea)
Surface Water	
Antimony	DMRQ
Cadmium	DMRQ
Zinc	DMRQ

The maximum detected level of 1,1-dichloroethene in groundwater from the Gallia aquifer in the vicinity of the X-740 unit (1.2 μg/L) exceeded the ten-day Health Advisory (1 μg/L) but not the one-day Health Advisory (2 μg/L). The maximum detected concentration of antimony (0.056 μg/L in a Berea sample from the X-744N unit) exceeded by about six-fold the Health Advisory of 0.01 μg/L. It should be noted that this maximum detect for antimony was an estimated ("J") value. In surface water, exceedences of the

short-term Health Advisories were noted for three inorganic compounds (antimony, cadmium and zinc), all of which occurred in surface water from the Don Marquis Substation (DMRQ).

The above analysis of potential for acute toxicity is limited by the available criteria. The analysis suggests that one organic and three inorganic compounds present in surface water and groundwater may pose some concern for acute effects if the surface water and groundwater were used as a drinking water source. As previously noted, however, groundwater below the PORTS site is not currently used as a potable resource and the ponded water at the DMRQ unit would not serve as a potable water body. Because background data for surface water and groundwater were not available at the time of this assessment, it is not possible to determine if the levels of the three inorganic compounds that exceeded their Health Advisories are within the ranges that occur naturally.

6.5.3.8 Assessment of Potential Off-Site Risks

6.5.3.8.1 Off-Site Risks under Current Use Conditions

Available RFI data do not provide direct measures of current exposures and potential risks for populations currently residing around the PORTS facility. Although off-site sampling of environmental media was not performed as part of the RFI, information useful to a qualitative assessment of the potential risks of facility releases to the off-site population under current land use conditions is contained in the annual environmental surveillance reports for PORTS prepared by Energy Systems for U.S. DOE (Energy Systems, 1988, 1989, 1990, 1991, 1992). Summaries of data relevant to an assessment of potential off-site exposures are contained in Appendix H.1 of this RFI. Among the media for which monitoring data are routinely collected and that provide information on potential

residential exposures are: food crops (including vegetables, fruit, milk, and eggs), vegetation, and soil. These biological samples and soil samples are generally analyzed for uranium, total alpha, and technetium. Vegetation samples are additionally analyzed for fluoride levels. Sampling locations fall into one of three groups: Group I includes sample points on or near the U.S. DOE Reservation boundary; Group II extends out to 5 km (3 miles) from the site; and Group III extends between 5 and 16 km (3 and 10 miles).

Based on analysis of the monitoring data in the annual environmental surveillance reports (Energy Systems, 1988, 1989, 1990, 1991, 1992; see selected data summarized in Appendix H.1), Martin Marietta Energy Systems has concluded that there is no significant contamination off-site of the PORTS plant site. A few samples have shown detectable levels of uranium or technetium or levels of these radionuclides above background (10 μg/g uranium, 10 pCi/g total alpha activity, or 1 pCi/g technetium beta activity in external soil samples); however, no pattern of contamination is discernable in the available monitoring data. For example, the 1987 environmental surveillance data showed elevated technetium levels in soil at one of 12 sample locations at the U.S. DOE property line. Vegetation samples taken from the same year showed no significant contamination, although one of 24 Group I (U.S. DOE property boundary) samples had a uranium level above the detection limit, one of 23 samples in Group I and one of 12 samples in Group II (within 5 km of the site) had detectable technetium levels, and one of 24 samples in Group I showed more than natural background alpha activity. In the most recent environmental surveillance reports for the years 1990 and 1991, none of the food crop samples had detectable levels of uranium or technetium. Only one vegetative sample from 1991 taken at a remote sampling location had a detectable technetium level; this detection was considered anomalous. In 1990, low levels of technetium (2 to 5 pCi/g) were measured at two sampling locations (one of which is a background location 10 miles upwind of the plant site); these results were also considered likely anomalous. Fluoride levels have not

shown a consistent pattern of elevation. While fluoride levels in Group I vegetation samples (which includes sample points on or near the U.S. DOE reservation boundary) showed a slight elevation in 1987 and 1989, Group I levels were lower than more remote locations (Groups II and III) in 1991. Overall, the environmental surveillance data for food crops, vegetation and soil do not show a pattern of contamination attributable to releases from the PORTS facility. The reader is referred to Appendix H.1 for a summary of selected off-site data from the environmental surveillance reports and to the annual environmental surveillance reports themselves for more detailed presentation and discussion of the surveillance data.

Energy Systems (1992) has estimated the total effective dose equivalent (EDE) that could be received by the maximally exposed off-site individual from airborne releases of radionuclides from PORTS based on 1991 emissions to be approximately 0.03 millirem (mrem) (see Part 2, Section 2 of Energy Systems (1992) for the basis of the calculated EDE). This EDE is well within the dose limit (10 mrem) specified under the Clean Air Act for U.S. DOE facilities. If the Scioto River were used for drinking water, fishing, and recreation by this maximally exposed individual, an additional 0.02 mrem could have been received. Again, even for a maximally exposed individual, this dose is well within the established limit.

As discussed in Section 6.3.3.1, no groundwater contamination has migrated off-site from Quadrant III. Therefore, groundwater does not present any risks to the residential population under current use conditions.

Local residents that hunt could potentially be exposed to constituents in PORTS media via consumption of local game (e.g., deer meat) that had grazed on the plant site.

As noted in the discussion of the future on-site recreational population, this potential pathway does not pose a significant risk.

6.5.3.8.2 Off-Site Risks Under Future Use Conditions

There are no definable groundwater plumes within Quadrant III and therefore no likelihood of off-site groundwater contamination currently or in the future. Available monitoring data do not provided any evidence of off-site contamination of soil or biota adjacent to Quadrant III. Therefore, based on the available data, constituents present in Quadrant III are not expected to present any risks in the future to off-site residential populations.

6.5.3.9 Assessment of Risks for Potential Laboratory Contaminants

At the time that the quantitative risk assessment for Quadrant III was conducted, nine chemicals that have been identified as common laboratory contaminants by the U.S. EPA were eliminated from the RFI. These are acetone, 2-butanone, methylene chloride, toluene, and five phthalate esters (diethylphthalate, di-n-butylphthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate). Subsequently, analytical data for these chemicals were re-evaluated according to U.S. EPA data validation guidelines. For a limited number of samples, detections of chemicals previously considered to reflect laboratory contamination were retained in the RFI based on the data validation effort. These detections are considered likely laboratory contaminants because, in most cases, their presence is sporadic and at levels only slightly above PQLs. Nevertheless, these constituents were evaluated in the BRA. A summary of data for all potential laboratory contaminants retained in the Quadrant III RFI by medium is presented in Table 6.270b.

Potential health risks associated with potential laboratory contaminants were evaluated in the BRA using a screening level methodology. Specifically, maximum concentrations of potential laboratory contaminants in each medium were compared to appropriate risk-based remedial action objectives (RAOs). The RAOs used for this analysis are chemical-specific concentrations that correspond to a noncancer HI of one or an excess cancer risk of 10^{-6}. Different sets of RAOs have been developed for soil, groundwater, surface water, and sediment. The derivation of risk-based RAOs is described more fully in Section 6.7.

Potential laboratory contaminants detected in Quadrant III media include acetone, 2-butanone, methylene chloride, toluene, and two phthalate esters (bis(2-ethylhexyl)phthalate and butylbenzylphthalate). Comparison of maximum detected concentrations of these chemicals to their RAOs (Table 6.270b) reveals that only one potential laboratory contaminant -- bis(2-ethylhexyl)phthalate -- exceeded its RAO. Specifically, in X-740 one detection of bis(2-ethylhexyl)phthalate in groundwater (16 μg/L) exceeded the RAO of 3.1 μg/L. The groundwater RAO is based on the future on-site residential scenario.

In all other cases, the measured concentrations of potential laboratory contaminants in Quadrant III media were less that their RAOs. A detection of a potential laboratory contaminant at a concentration below its RAO indicates a hazard quotient less than one or an excess lifetime cancer risk less than 10^{-6}. In other words, these detections present no significant health risk under the assumptions applied in the BRA.

Thus, only bis(2-ethylhexyl)phthalate in one groundwater sample (X-740) exceeded its respective RAO and presents an excess cancer risk greater than the U.S. EPA target risk level of 10^{-6}.

6.5.4 Uncertainties in the Risk Assessment Process

Risk assessment provides a systematic means for organizing, analyzing, and presenting information on the nature and magnitude of risks posed by exposures to environmental contaminants. Nevertheless, uncertainties are present in all risk assessments because of the number of assumptions about exposure and toxicity. A discussion of quantitative risk estimates, therefore, is not complete without recognition and consideration of these uncertainties.

In general, the uncertainties in a risk assessment fall into two broad categories: those associated with the exposure assessment and those associated with the toxicological assessment. In the following, uncertainties are identified for each of these categories. When possible, a qualitative discussion of the potential effect of the uncertainty on the risk estimate is also included. In general, the magnitude of uncertainties that may affect risk estimates by less than one order of magnitude are categorized as "small;" those that may affect risk estimates by between one and two orders of magnitude are categorized as "moderate;" and those that may affect risk estimates by more than two orders of magnitude are categorized as "high." It is important to recognize that the uncertainties listed below are neither additive nor mutually exclusive. Therefore, summing the values associated with each uncertainty to derive an overall estimate of the magnitude of uncertainty in the risk values is not appropriate.

Table 6.271 summarizes the major uncertainties in this BRA.

6.5.4.1 Uncertainties Associated with the Exposure Assessment

Environmental Sampling

A more extensive data base of uniformly high quality data (e.g., data formerly referred to as Level 3 data) will generally be associated with less uncertainty than a smaller data base. The SWMU-specific analyses prepared here are, for the most part, based on relatively few media samples. How representative the samples are of the entire SWMU is unknown. In calculating the reasonable maximum exposure, the maximum concentration for each constituent in a given medium was used as a best available conservative estimate of the environmental concentration to minimize the likelihood that exposures would be underestimated. This assumption is likely to overestimate potential exposures. The potential magnitude of risk overestimation associated with this uncertainty is considered moderate.

Laboratory Measurement

The quality of the analytical data used in a risk assessment depends on the adequacy of the set of rules or procedures that specify how samples were selected and handled, i.e., the sampling plan. Uncertainties that may be associated with the data include sampling errors, laboratory analysis errors, and data analysis errors. The QA/QC review procedures used to minimize these uncertainties and the QA/QC Summary Report are presented in Appendix C of this RFI. The potential magnitude of risk over or underestimation associated with this uncertainty is considered small.

Total Metals vs. Total Mobile Metals Groundwater Data

Phase I groundwater samples were analyzed for total metals and dissolved metals. Phase II groundwater samples were analyzed for total metals and total mobile metals. Total mobile metals data may more accurately represent possible contamination in groundwater that may be used for drinking. Because both sets of data were combined for purposes of the risk assessment, however, only total metals data were considered. A thorough analysis of groundwater metals data and comparison to background will be addressed in the CAS/CMS. Preliminary analysis indicates, however, that concentrations of total metals are generally greater than total mobile metals, and that use of the former would generally overestimate risks.

A preliminary analysis of the extent to which risks may be overestimated for inorganic constituents in groundwater was performed for two groundwater data sets with relatively high levels of inorganic constituents. These data sets are X-230J3 groundwater (Quadrant III) and X-230J6 groundwater (Quadrant IV). This analysis was limited to the two inorganic constituents that contributed most to excess cancer risk, arsenic and beryllium. A comparison of the RME concentrations and associated risks is presented below.

Comparison of Total Metals and Total Mobile Metals Data for Groundwater				
	Total Metals		Total Mobile Metals	
Inorganic Constituents	RME Conc. (mg/L)	Estimated Cancer Risks (residential scenario)	RME Conc. (mg/L)	Estimated Cancer Risk (residential scenario)
SWMU: X-230J3				
Arsenic	0.5	1×10^{-2}	0.024	5×10^{-4}
Beryllium	0.0067	4×10^{-4}	<D.L.	--
Total risks:		$>10^{-2}$		5×10^{-4}
SWMU: X-230J6				
Arsenic	0.35	7×10^{-3}	<D.L.	--
Beryllium	0.0056	3×10^{-4}	<D.L.	--
Total risks:		8×10^{-3}		--
NOTES: <D.L. = below detection limit.				

As the above comparison shows, excess cancer risks using total metals data are substantially higher than those obtained using total mobile metals data. In the example using selected data from the X-230J3 unit, excess cancer risks using total metals data, assuming use of groundwater as a domestic source, is about 20-fold greater than the excess cancer risk would be using total mobile metals data. In the example using selected data from the X-230J6 unit, risks associated with total metals concentrations are significant (8×10^{-3}); however, no quantifiable risks are posed by inorganic constituents if total mobile metals data are used because all sample concentrations are below the limit of detection. Based on this limited analysis, it appears that the potential magnitude of overestimating risk associated with this uncertainty is high.

Calculation of RME Media Concentration

According to U.S. EPA (1992e), a minimum of 20 samples is required to provide fairly consistent estimates of the 95 percent UCL. In the Quadrant III RFI, greater than 20 samples are available for nine data sets (for soil: X-330 [0-10 ft], X-530A [0-2 ft and 0-10 ft], X-744S [0-10 ft], X-745C [0-2 ft and 0-10 ft], BFS [0-10 ft], and DMRQ [0-2 ft]; for groundwater: X-616 [Gallia]). In these instances, the calculated 95 percent UCL would likely be lower than the maximum detected concentration. Use of the maximum concentration for these SWMUs would likely overestimate the RME concentration. The potential magnitude of risk overestimation associated with this uncertainty is considered moderate.

For those cases where the 95 percent UCL was determined, this value, as suggested by U.S. EPA (1992a), was calculated assuming that the data were distributed lognormally. It appears, however, that for quadrant-wide shallow and deep soils, the data sets for several chemicals may not be distributed lognormally. As a result, the calculated 95 percent UCL is lower than the arithmetic mean concentration. Recalculating the 95 percent UCL using the "t" statistic (which would give a reasonably good approximation of the 95 percent UCL even if the data are not truly distributed normally) would increase the RME concentrations by a factor of two or three. Because risks are linearly dependent on exposure concentrations, risks could therefore increase by a factor of two or three. This uncertainty is assumed to have a potentially low effect on underestimating risks.

Some risks may be artifacts of the standard procedure by which analytical results are handled. For chemicals detected in some samples of a given medium, the average exposure concentration is calculated by assigning to those samples with the constituent below the detection limit a concentration of one-half the practical quantitation limit. In

cases where quantitation limits are relatively high and when the chemical may not even be present in the nondetect samples, this procedure can inflate (by some unknown amount) the calculated exposure point concentration and ultimate risks. The potential magnitude of risk overestimation associated with this uncertainty is considered moderate. This procedure can also result in an overestimation of background, which may result in failure to include actual site-related contaminants as chemicals of potential concern. In this latter situation, risks may be underestimated. Because of the relatively high detection frequency for most naturally occurring inorganics, the potential magnitude of risk underestimation associated with this uncertainty is considered small.

Calculation of Quadrant-Wide Average Concentrations

For three scenarios considered in this BRA -- ingestion of beef, milk, and game -- concentrations of constituents in meat or milk were modeled based on the average (or more specifically, the 95 percent UCL on the average) concentration of constituents in all soil samples across the quadrant. A quadrant-wide average concentration was used in assessing these exposure pathways because it is unreasonable to assume that livestock or game species would be restricted to individual SWMUs. The calculation of concentrations in beef, milk, and deer meat as performed in this BRA implicitly assumes that contamination is uniform across the quadrant. In fact, in Quadrant III, approximately 25% of the entire quadrant is covered by SWMUs where soil investigations were conducted and therefore where surficial soil contamination may occur. It is likely that much of the grazing time for livestock and game would be spent on areas not influenced by plant activities and therefore not contaminated. The assumption made that the average concentrations of soil constituents from sampled SWMUs applies to soils across the quadrant is assumed to have a low to moderate effect on overestimating beef, milk, and deer meat concentrations and on overestimating corresponding risks from these pathways.

Uncertainties in Mathematical Fate and Transport Modeling

An additional area of uncertainty in the exposure assessment follows from the use of mathematical models to predict the fate and transport of chemicals. In fact, for some SWMUs, indirect exposure pathways that involve fate and transport modeling pose a significant risk. Use of such models is well accepted in the professional engineering community and is endorsed by U.S. EPA in its Superfund Exposure Assessment Manual (U.S. EPA, 1988c). U.S. EPA does not, however, provide specific guidance concerning the selection of specific models from among a wide variety available for a given purpose. Indeed, the trade-off between simplicity, generality, and accuracy is best made by considering the needs of and available data for the site in question.

Because few environmental models have been authoritatively verified by field observations, there is some uncertainty associated with the use of a mathematical model for predicting environmental quality. In general, the selected models have been developed by contractors to U.S. EPA or have been used by U.S. EPA regulators and scientists for assessments similar to the one conducted here. In accordance with U.S. EPA guidelines, conservative assumptions have been generally made in an effort to overestimate rather than underestimate risk. The potential magnitude of risk overestimation associated with model uncertainties is considered moderate.

For the beef, milk, and game models, ingestion of contaminated surface water or groundwater is not considered in the current assessment. For the vegetable model, irrigation with contaminated groundwater or surface water is also not considered. The potential magnitude of risk underestimation associated with this uncertainty is considered small. For the volatiles and particulates in air models, standard default values were used. The potential magnitude of risk over- or underestimation associated with this model

uncertainty is considered small. However, in each case, the conservative assumptions discussed above would likely result in the net effect of overestimating risks.

Background Analyses

An analysis of background levels of naturally occurring compounds in soil based on tentative background values was included previously in the RFI risk assessments for Quadrants I, II, III, and IV, and has been included in the current Quadrant III Phase II assessment of soils. Re-evaluation of potential risk associated with background levels of naturally occurring or other non-plant-related constituents in soil may change based on the analysis of approved soil background values presented in the BSI (U.S. DOE, 1996a).

Background data are not available for sediments and surface water, and were not available for groundwater at the time the quantitative risk assessment was performed. Therefore, any risks associated with inorganic compounds and uranium in these media may actually be attributable, at least in part, to background levels of naturally occurring substances. For groundwater, surface water, and sediments, therefore, risks attributable to the facility are likely to have been overestimated. Evaluation of groundwater background data using the results presented in the BSI, which will be addressed in the CAS/CMS, will provide more reasonable estimates of potential exposures and risks attributable to PORTS. The potential magnitude of risk overestimation associated with this uncertainty is considered moderate. Risks associated with chemicals in soil may be underestimated if the situation occurs where chemicals of potential concern are added based on a comparison to background values presented in the BSI report.

RME Scenario

For each exposure pathway modeled, assumptions were made about the number of times per year an activity could occur, the routes of exposure by which an individual could be exposed, the amount of contaminated media to which an individual could be exposed by the activity, and the intake of each substance by each route of exposure. In the absence of site-specific data, the assumptions used in this BRA are generally those consistent with U.S. EPA guidance for deriving estimates of the RME case (U.S. EPA, 1989a, 1990b, 1991a). The RME scenario was intended to estimate a conservative exposure case that is within the range of possible exposures but well above the average case. It should be noted, however, that many of the exposure variables recommended by U.S. EPA for the RME case represent 90th to 95th percentile values. When several upper bound values (i.e., 90th or 95th percentile values) are combined in estimating exposure for any one pathway, resulting risk estimates may well be in excess of the 99th percentile exposure and thereby outside the range of exposures that might reasonably be expected to occur at a site. The potential magnitude of risk overestimation associated with this uncertainty is considered moderate.

For some of the scenarios, use of U.S. EPA default exposure assumptions is likely to result in estimates of exposure that are substantially higher than actual exposures. For example, the assumption is made in the current on-site worker scenario that a worker is exposed to media within an individual SWMU for the entire duration of employment (i.e., 8 hours/day, 5 days/week, 50 weeks/year, for 25 years). In fact, each of the SWMUs is relatively small, so that only a fraction of the work week might involve any potential contact with SWMU-specific media. In the absence of site-specific data, the same assumptions for on-site worker exposure applied to SWMUs with soil data were also applied to SWMUs with sediment and surface water data (i.e., the West Drainage Ditch,

the X-230J5 West Holding Pond, the X-2230N West Holding Pond No. 2, and the Don Marquis Substation containment ponds and drainage ditches). Because regular worker contact with these SWMUs is highly unlikely, potential risks associated with sediment and surface water for the on-site worker are likely overestimates. This is particularly true of the assessment of leachate samples from the West Drainage Ditch seep. In this case, contact by either an on-site worker or future recreational population is highly unlikely to be regular and frequent as assumed in the exposure assessment for this unit. Assessments such as this should be considered screening level assessments. The potential magnitude of risk overestimation associated with use of conservative exposure assumptions is considered moderate to high.

In a limited number of instances, exposures (and potential risks) associated with worker contact with soil and groundwater for a given SWMU were evaluated in addition to exposures (and potential risks) associated with worker contact with sediment and surface water for the same SWMU (e.g., see the assessment for the X-2330N West Holding Pond No. 2). In these instances, soil/groundwater exposures were estimated separately from sediment/surface water exposures because each exposure estimate was based on a set of generic RME assumptions. Combining two estimates of exposure (i.e., soil/groundwater and surface water/sediment) each based on RME assumptions would result in a total exposure that reasonably would not be expected to occur. To the extent, however, that workers in a given SWMU could be exposed regularly to multiple media over an 8-hour work period, potential risks could be underestimated in the current Quadrant III risk assessment for this population.

Exposures of Young Children as a Sensitive Subpopulation

For some pathways of exposure, children may be at higher risk because of their relatively greater exposure when adjusted for body weight (ingestion of soil or sediment and milk). In the evaluation of carcinogenic risk, this relatively greater exposure of children was included in the estimate of average lifetime exposure. For the assessment of the potential for noncarcinogenic effects, the HI values for all pathways, including ingestion of soil, sediment and milk, were based on the potential intakes for the adult because HI values for different age groups are not additive. Therefore, noncancer HI values may be underestimated for the most sensitive population because risks for children can be several fold higher than those for an adult. Because the exposure assumptions used in the current assessment are highly conservative, the assessment is still considered protective of young children and other sensitive populations. The potential magnitude of risk underestimation associated with this uncertainty is considered small to moderate.

Risk Assessment for Essential Nutrients

U.S. EPA guidance in RAGS suggests that chemicals that are essential nutrients (such as iron, magnesium, calcium, potassium, and sodium) and that are present at low concentrations (i.e., only slightly elevated above naturally occurring levels) need not be considered further in the risk assessment. In this assessment of SWMUs in Quadrant III of PORTS, essential nutrients were not deleted from the risk assessment. The decision not to delete essential nutrients from the assessment was based in part on U.S. EPA comments on the Quadrant I and II RFI Draft Final Reports and on U.S. EPA comments on the July 23, 1992 Responses to Comments (March 18, 1994). In the most recent comments, U.S. EPA stated that "U.S. DOE should retain all toxicants including essential elements, for the risk assessment."

None of the naturally occurring compounds that might be considered essential nutrients contributes significantly to risk. Therefore, the potential magnitude of risk overestimation associated with this uncertainty is considered small.

Estimates of Dermal Exposure to Constituents in Soil

Of the direct exposure pathways for which estimates of exposure were developed, the pathways involving dermal exposure to constituents in soil and water are subject to particularly high uncertainty.

As stated in U.S. EPA (1992c) with respect to dermal exposure to constituents in soil, the parameters required to estimate exposure to compounds in a soil matrix have not been well characterized, and major uncertainties exist in the extent to which a chemical is percutaneously absorbed and in the extent to which a chemical will partition from soil to skin.

One of the parameters required to estimate dermal exposure to chemicals in soil is the dermal absorption factor (i.e., the unitless factor that indicates the absolute amount of chemical in soil that will be absorbed dermally). In the current assessment for chemicals present in Quadrant III soils, the following dermal absorption factors were used, based on the recommendations of U.S. EPA and OEPA provided to U.S. DOE in April 1994.

Chemical Group	Dermal Soil Absorption Factor
Volatile organic compounds (VOCs)	0.25 (25%)
Semi-volatile organic compounds (SVOCs)	0.1 (10%)
PCBs	0.06 (6%)
Inorganic compounds	0.01 (1%)

The above-recommended dermal absorption factors were not incorporated in the risk assessments in the Quadrant I and II RFI final reports. Rather, the factors used in the Quadrant I and II risk assessments were as follows: VOCs -- 10%, SVOCs -- 1%, and inorganic compounds -- 0.1%. Thus, the dermal absorption factors used in the Quadrant III RFI are larger by 2.5- to 10-fold than those used in the final RFI risk assessments for Quadrants I and II. In general, the available experimental data are insufficient to verify which set of default factors is more appropriate. For only a limited number of chemicals (including dioxin, PCBs, and cadmium) are there sufficient data to estimate dermal absorption factors. No data on dermal absorption from a soil matrix are available for VOCs or SVOCs. Thus, in the absence of a more extensive data base of experimentally derived values, the uncertainty about dermal absorption values is substantial.

Estimates of Dermal Absorption of Organic Constituents in Water

In this risk assessment, dermal absorption of organic constituents in water was estimated using a steady state model and a permeability coefficient (PC) calculated using a regression equation developed by Brown and Rossi (1989).

For organic chemicals, U.S. EPA (1992c) has proposed a nonsteady state model for estimating dermal exposure to organic constituents in water and an alternative regression equation for calculating the PC. While the nonsteady state model has conceptual

advantages over the traditional steady state approach and provides a more conservative estimate of total absorbed dose, U.S. EPA (1992c) cautions that the proposed procedure for organic chemicals is based on a model recently developed by Cleek and Bunge that has not been validated and is currently undergoing review by the scientific community. Preliminary testing of the new approach by the agency has provided results that appear counterintuitive and raise concerns that the model may be overly conservative. U.S. EPA concludes that "the final dose and risk estimates must be considered highly uncertain" and that "the procedures for estimating the dermal dose from water contact ... must be approached with caution" (U.S. EPA, 1992c).

Thus, irrespective of the model used, substantial uncertainty is associated with estimates of exposure and risk from dermal contact with water.

Use of 50th Percentile Body Surface Area

In evaluating the RME exposure resulting from potential whole body contact with groundwater or surface water (i.e., showering or swimming scenarios), a 50th percentile body surface area and 70-kg body weight were assumed. A 50th percentile body surface area value was used along with the average (70-kg) body weight because of the strong correlation between surface area and body weight (U.S. EPA, 1989a). An upper-end (95th percentile) value for body surface area of 23,000 cm^2 is also presented in U.S. EPA (1992c). As shown in the following example based on the future use worker scenario, use of this upper-end body surface area value would not significantly influence risk estimates.

The 50th percentile body surface area of 19,400 cm^2 (U.S. EPA, 1990b) assumed in developing dermal exposure estimates for the worker exposed during showering is 18 percent smaller than the 95th percentile value of 23,000 cm^2 provided in U.S. EPA

(1992c). Because the exposure equation is linear, estimated dermal exposures for the on-site worker using the 95th percentile total body surface area would be 18 percent greater than the exposures estimated in the current assessment. The estimated exposures associated with dermal exposure while showering, however, are one to two orders of magnitude smaller than the estimated exposures received through ingestion of groundwater. Therefore, the increase in exposure to groundwater from dermal contact using a 95th percentile body surface area value rather than a 50th percentile value would not significantly alter the estimated total risk for the future on-site worker.

Risk estimates for two other scenarios -- (1) dermal contact by the future on-site resident while showering and (2) dermal contact by the future on-site recreational population while swimming -- also used total body surface area as a variable in estimating exposure to contaminants in groundwater or surface water. Risk estimates would similarly not be significantly increased by use of the upper-end body surface area value rather than 50th percentile value as was used in the current assessment.

6.5.4.2 Uncertainties Associated with the Toxicological Assessment

In the great majority of risk assessments, as in the current risk assessment, available scientific information is insufficient to provide a thorough understanding of all the toxic properties of chemicals to which humans are potentially exposed. It is generally necessary, therefore, to infer these properties by extrapolating them from data obtained under other conditions of exposure, generally in laboratory animals.

Experimental animal data have been relied upon for many years by regulatory agencies and other expert groups for assessing the hazards and safety of human exposure to chemicals. This reliance has been supported in general by empirical observations.

There may be differences in chemical absorption, metabolism, excretion, and toxic response, however, between humans and the species for which experimental toxicity data are generally available. To the extent that data permit, U.S. EPA takes into account differences in body weight, surface area, and pharmacokinetic relationships between animals and humans to minimize the uncertainties associated with extrapolation of animal data. Uncertainties in using animal data to predict potential effects in humans are also introduced when routes of exposure in animal studies differ from human exposure routes; when the exposures in animal studies are short-term or subchronic; and when effects seen at relatively high exposure levels in animal studies are used to predict effects at the much lower exposure levels found in the environment. The methods for dealing with these uncertainties in the toxicological assessments for noncarcinogens and carcinogens are discussed below.

Uncertainties in the Characterization of the Toxicity of Noncarcinogens

In order to adjust for uncertainties such as those discussed above, regulatory agencies often base the acceptable daily intake (or for U.S. EPA, the RfD or RfC) for noncarcinogenic effects on the most sensitive animal species, i.e., the species that experiences adverse effects at the lowest dose. This dose is then adjusted via the use of safety factors or uncertainty factors in order to compensate for lack of knowledge regarding interspecies extrapolation and to guard against the possibility that humans are more sensitive than the most sensitive experimental animal species tested. Therefore, an exposure at the RfD or RfC is an exposure generally several orders of magnitude lower than an exposure shown to cause demonstrable adverse effects. U.S. EPA (1994a,b) generally considers RfDs to be accurate within an order of magnitude. The potential magnitude of risk overestimation associated with this uncertainty is considered small to moderate.

Uncertainties in the Characterization of the Toxicity of Chemical Carcinogens

For many chemicals that are carcinogenic in animals, there is uncertainty as to whether they are also carcinogenic in humans. While many chemicals are carcinogenic in one or more animal species, only a small number of substances are known to be human carcinogens. The fact that some chemicals are carcinogenic in some animals but not in others raises the possibility that not all animal carcinogens are human carcinogens, as well as the possibility that not all human carcinogens are animal carcinogens. The finding that relatively few substances are known human carcinogens may be due in part to the difficulty in performing adequately designed epidemiologic investigations in exposed human populations. Regulatory agencies generally assume that humans are as sensitive to carcinogens as the most sensitive animal species. This is a policy decision designed to prevent underestimating carcinogenic risk. In addition, there are several mathematical models available to derive low-dose SFs from high exposure levels used in experiments. The model used by U.S. EPA is the linearized multistage model, which provides a conservative estimate of risk at low doses (i.e., the model is likely to overestimate the actual SF). Several of the alternative models often predict lower risk at low doses, sometimes by orders of magnitude. Thus, the use of the linearized multistage model ensures a conservative estimate of the SF. The lack of knowledge regarding the validity and accuracy of this model, however, contributes to the uncertainties in cancer risk estimates.

For suspected carcinogens, the procedure used by U.S. EPA and most other regulatory agencies is to use the 95 percent upper confidence limit estimated by the linearized multistage model. Use of the 95 percent upper confidence limit value rather than the SF that represents the maximum likelihood estimate provides an estimate of the upper bound on risk.

One step in the methodology used by U.S. EPA to estimate an SF from the animal data involves interspecies scaling (i.e., extrapolation) of dose from laboratory animals to humans in order to compensate for differences in such factors as size, lifespan, and basal metabolic rate. The U.S. EPA has historically extrapolated doses on the basis of milligrams of chemical per square meter body surface area per day ($mg/m^2/day$), equivalent to body weight to the ⅔ power. More recently, however, a draft consensus document authored by U.S. EPA, the U.S. Food and Drug Administration (U.S. FDA), and the Consumer Product Safety Commission (CPSC), "Draft Report: A Cross-Species Scaling Factor for Carcinogen Risk Assessment Based on Equivalence of $mg/kg^{3/4}/day$" (U.S. EPA, 1992d), and U.S. EPA's "Proposed Guidelines for Carcinogen Risk Assessment" (U.S. EPA, 1996a) have proposed a scaling factor of body weight to the ¾ power. U.S. EPA (1992d) noted that, "as the basis for a common and unified science policy among these three agencies on a default methodology for determining equivalence of doses ... when extrapolating results of rodent carcinogen bioassays to humans," that doses be expressed in terms of body weight raised to the 3/4 power. This scaling factor was selected by the Federal agencies because it is supported by the empirical data and to provide a single, consistent methodology across the agencies. Use of the default scaling factor of body weight to the 3/4 power results in cancer SFs that are smaller, by several fold, than those developed with the body surface area scaling factor. Therefore, the SFs for chemicals of potential concern in this risk assessment probably overestimate by several fold the risks that would be estimated using the recently proposed scaling factor. The potential magnitude of risk overestimation associated with this uncertainty is considered small.

Uncertainties in the Characterization of the Toxicity of Radionuclides

The uncertainty in cancer risk factors for radionuclides is generally smaller than in SFs for most chemical carcinogens because the former values are extrapolated from human

epidemiologic data. In addition, radiologic risks factors generally represent best estimate values of the extrapolated data rather than an upper confidence limit.

Uncertainties in the Characterization of the Toxicity of Inorganic Compounds

When performing animal toxicity studies for inorganic compounds, the most soluble form of the compound is normally administered. In the field, inorganic compounds are more typically present in a relatively insoluble form, especially in surface soils. To the extent that the form of the inorganic compound in the field is less soluble than the form used in the study that forms the basis of the SF or RfD, the exposure and potential risk may be overestimated by an order of magnitude or more. To reduce this uncertainty, it would be necessary to perform complete analyses to determine the anions (e.g., sulfate, nitrate, etc.) with which the cations are associated (i.e., determine the actual form of the inorganic compounds present in the field). The potential magnitude of risk overestimation associated with this uncertainty is considered moderate.

Uncertainties Introduced by Lack of Toxicity Values

In most risk assessments, chemicals are present for which quantitative risk estimates cannot be prepared because little or no information on the toxicity of the chemical appropriate for quantitative risk assessment is available. In the current BRA, per the policy of U.S. DOE, only toxicity values (i.e., RfDs, RfCs, and cancer SFs and unit risks) were used and applied to the route of exposure for which the toxicity value had been developed. In other words, an oral SF was used to estimate cancer risk by oral pathways only. (The one exception is for the assessment of risks from dermal exposure, in which oral toxicity values were adopted for assessing dermal risks.)

For pathways involving oral routes of exposure, the uncertainty introduced by lack of route-specific toxicity values is relatively low because toxicity values have been developed for most of the chemicals of potential concern. For exposure received via inhalation, the uncertainty is moderate because U.S. EPA has developed fewer toxicity values specific to inhalation. Thus, in particular for the inhalation exposure pathways, risks may be underestimated because of the lack of U.S. EPA-derived route-specific toxicity values for some of the chemicals of potential concern. The magnitude of this uncertainty is dependent on the number of chemicals detected in a given SWMU and the extent to which toxicity data are available for these chemicals.

Dermal toxicity values derived from oral toxicity values may not be appropriate for some chemicals, such as PAHs, that have a direct effect on the skin when applied dermally. In these situations, the approach used can result in an underestimation of potential risk. The route of entry can also influence the toxicant concentration that reaches the liver. For example, the concentration of a chemical reaching the liver via the portal system following gastrointestinal absorption could be greater than that reaching the liver following dermal absorption. This situation would lead to an overestimation of potential risk.

Uncertainties Associated with Individual Chemicals or Chemical Groups

A number of chemicals in PORTS media contribute to the overall potential cancer and noncancer risks associated with contact with these media under current or future use conditions. While there is uncertainty about the risk estimates derived for each of the constituents detected in PORTS media, the uncertainties associated with the toxicity assessments for several chemicals or chemical groups, specifically PAHs, PCBs, and arsenic, deserve further consideration. These uncertainties are discussed in the following paragraphs.

Polycyclic Aromatic Hydrocarbons (PAHs). The assessment of carcinogenic risk posed by PAHs was based on U.S. EPA's "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons" (U.S. EPA, 1993b). This provisional guidance recommends that a series of relative potency values (orders of magnitude) be used for the risk evaluation of oral exposure to PAHs, with the potency of individual PAHs being compared to that of benzo(a)pyrene. Research to better understand the nature of the potency of mixtures of PAHs is in progress. The magnitude of uncertainty introduced by the current relative potency scheme in over or underestimating cancer risk of PAHs from oral exposure is unknown.

There is currently no inhalation unit risk for benzo(a)pyrene or other PAHs. To the extent that inhalation of PAHs contributes to total cancer risk, such risk is underestimated in the current assessment.

Polychlorinated Biphenyls (PCBs). PCBs are a class of synthetic organic compounds that share the same basic biphenyl structure (12 carbons arranged into two rings), with a varying number of chlorine atom substitutions. Various commercial mixtures of PCBs with different degrees of chlorination were sold under trade names such as Aroclor, Clophen, and Kaneclor. Aroclors are identified by a four-digit numeric code in which the first two digits (12) indicate that the product is a biphenyl structure with twelve carbons and the last two digits indicate the chlorine weight content. For example, Aroclor 1248 is a biphenyl with an average chlorine content of 48 percent, and Aroclor 1260 is a biphenyl with an average chlorine content of 60 percent.

At the time of conduct of this quantitative risk assessment, the U.S. EPA SF for PCBs was 7.7 $(mg/kg/day)^{-1}$, based on the Norback and Weltman bioassay of Aroclor 1260 in rats. U.S. EPA policy at the time was to apply this SF to all PCB mixtures, while

acknowledging that "it is known that PCB congeners vary greatly as to their potency in producing biological effects," and that "[t]here is some evidence that mixtures containing more highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats than mixtures containing less chlorine by weight" (U.S. EPA, 1994a). Recently, the U.S. EPA (1996b) completed a reassessment of the carcinogenicity of PCBs that took into consideration the results of a 1996 study of Aroclors 1260, 1254, 1242, and 1016 in the rat. One outcome of this reassessment is the Agency recommendation that cancer potency be determined using a tiered approach that depends on the information available, including information on route of exposure; presence of dioxin-like, tumor-promoting, or persistent congeners; and degree of chlorination. In addition, U.S. EPA has derived both central estimate and upper-bound SFs for PCBs, either of which may be appropriate depending on the specific application. The PCB cancer potency estimates resulting from this recent U.S. EPA reassessment range from 0.04 $(mg/kg/day)^{-1}$ to 2.0 $(mg/kg/day)^{-1}$. These potency estimates are approximately 4- to 200-fold smaller than that used in the current assessment. Thus, use of the previously verified U.S. EPA SF in the current assessment results in an overestimate of potential cancer risk associated with PCBs.

Arsenic. U.S. EPA has classified inorganic arsenic as a Category A carcinogen, or known human carcinogen. U.S. EPA's oral quantitative estimate of carcinogenic potency is based on a study by Tseng et al., which reported increased prevalence of skin cancers in humans as a consequence of arsenic exposure in drinking water (U.S. EPA, 1994a). When using this potency estimate in risk assessment, consideration should be given to the degree of uncertainty in the arsenic cancer slope factor articulated by U.S. EPA in IRIS (U.S. EPA, 1994a). The Administrator of the U.S. EPA has counseled that "In reaching risk management decisions in a specific situation, risk managers must recognize and consider the qualities of risk estimates. The uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards by as much

as an order of magnitude, relative to risk estimates associated with most other carcinogens" (U.S. EPA, 1994a). As noted by U.S. EPA (1994a), "[t]he carcinogenicity assessment for arsenic my change in the near future pending the outcome of a further review now being conducted by the Carcinogen Risk Assessment Verification Endeavor Work Group."

Chromium Speciation

For purposes of the BRA, the conservative assumption was made that all chromium present in media at PORTS is the more toxic chromium (VI). In fact, it is more likely that the chromium species present in the enviroment at PORTS is chromium (III). Because the RfD for chromium (VI) is 200 times smaller than the RfD for chromium (III) and because only chromium (VI) is considered to be carcinogenic by inhalation, the assumption that all environmental chromium is in the +6 valence state is likely to substantially overestimate the potential health risk associated with this inorganic compound.

Mixtures

In the absence of information on the toxicity of specific mixtures (which is rarely available), the procedure generally applied to the case of simultaneous exposure to multiple chemicals from a variety of sources assumes dose additivity. This procedure has been applied in the assessment of PORTS.

For noncarcinogens, the HI approach presented in U.S. EPA's (1986) Guidelines for Health Risk Assessment of Chemical Mixtures and described earlier in this section has been used to assess risks from multiple chemical exposure. Limitations of this approach include the following (U.S. EPA, 1989a):

- Little is generally known about the effects of mixtures of chemicals; although additivity is generally assumed, it is possible that the interaction of multiple chemicals could be synergistic or antagonistic.

- The RfDs and RfCs do not have equal accuracy or precision and are not based on the same severity of effect.

- Dose additivity is most properly applied to compounds that induce the same effect by the same mechanism of action. While the HI approach is a useful screening-level approach, the potential for noncarcinogenic effects to occur can be overestimated for chemicals that act by different mechanisms and on different target organs. Where HIs exceeded one, an analysis to determine the appropriateness of HI segregation by toxic endpoint/mechanism of action was performed. This analysis is presented in the following section.

Limitations to the approach for estimating cancer risks from multiple chemical exposure are recognized and discussed in U.S. EPA (1989a). First, risks are based on SFs that represent an upper 95th percentile estimate of potency, and upper 95th percentiles of probability distributions are not strictly additive. Summing such individual cancer risks can result in an excessively conservative estimate of total lifetime cancer risk. Secondly, the action of two carcinogens may not be additive, especially if the target organs upon which they act are different. Third, the procedure for summing cancer risks for multiple chemicals gives as much weight to class B and C carcinogens (probable and possible human carcinogens, respectively) as to class A (known human) carcinogens. The significance of this last uncertainty in Quadrant III is discussed further below. In the absence of data to the contrary, however, additivity is assumed for multiple carcinogens.

Estimates of the total lifetime risk of cancer from exposure to radionuclides and chemical carcinogens have been summed to determine the overall potential human health hazard associated with PORTS media. In so doing, it is important to recognize some inherent difference in toxicity characterization for chemical carcinogens and radionuclides. Cancer SFs for chemicals are based primarily on experiments in laboratory animals and generally represent upper bound or 95th percent confidence limit values to account for the uncertainty in extrapolating from laboratory animal data to humans. For radionuclides, in contrast, human epidemiologic data form the basis of the extrapolation. Further, radionuclide risk factors generally represent best estimate values of the extrapolated data. The procedures used to derive chemical carcinogen SFs produce more conservative toxicity values. Consequently, risk estimates for chemical carcinogen mixtures will tend to be more conservative than for radionuclide mixtures.

Segregation of Hazard Index by Effect

As stated above, the assessment of overall potential for noncarcinogenic effects posed by more than one chemical was performed by summing the HQ values for all noncarcinogenic chemicals to derive an HI for that exposure pathway. This procedure is most properly applied to compounds that induce the same effect by the same mechanism of action. Application of the HI approach to a number of chemicals that are not expected to induce the same type of effects or that do not act by the same mechanisms could overstate the potential for adverse effects to occur (U.S. EPA, 1989a).

In the majority of the assessments of potential noncancer risk for SWMUs in Quadrant III, HI values were one or less. Thus, even with the application of the conservative practices inherent in the HI approach, the assessment indicates that potential exposures to chemicals in PORTS media do not pose a risk of noncancer effects. In these

cases, segregation of chemicals by effect or mechanism of toxicity would not result in a different finding. Where the assessments of individual SWMUs result in an HI greater than one, in most cases the HI greater than one is due to the presence of one or two noncarcinogens, each of which has an HQ value greater than one. In these cases, segregation of chemicals by effect or mechanism of toxicity is again not warranted. For only one SWMU in Quadrant III, the HI is greater than one as a consequence of summing several HQ values less than one. Segregation of the compounds by effect or mechanism may be appropriate in these cases. Segregation of HQs by endpoint and the consequences for the assessment of potential noncancer risk is presented below.

It should be noted that segregation of HIs, if performed in a rigorous fashion, is not a simple analysis. The analysis performed as part of this risk assessment was limited to the most sensitive endpoint for each chemical, and did not systematically take into account all major target organs and effects of each chemical nor mechanism of action. The segregation of HI values performed here, however, does provide a reasonable refinement of the HI and additional information useful to a determination of whether or not multiple constituents in a given medium pose a noncancer hazard.

(Note: for purposes of the analysis performed here, HQ and HI values are presented with two significant figures. Elsewhere, HI and HQ values are presented with one significant figure.)

- *Gallia groundwater Well F-31G: Ingestion of water by the resident under future use conditions.* Ingestion of groundwater from the Gallia aquifer by the future on-site resident from the vicinity of groundwater well F-31G presents a cumulative HI of 1.6. The HI is largely attributable to several

inorganic compounds, primarily barium, chromium, nickel, and vanadium, each of which is associated with an HQ less than one.

In the case of the F-31G well, an HI greater than one resulted from the potential exposure to several inorganic compounds. The endpoints of toxicity upon which the RfD is based are presented below for these inorganic compounds.

Chemical	Endpoint upon which the RfD is based
Barium	Increased blood pressure in humans
Chromium	No effects were observed in the one-year drinking water study upon which the RfD was based
Nickel	Decreased body and organ weights
Vanadium	No effects were observed in the lifetime drinking water study upon which the RfD was based
Zinc	Blood chemistry

Because the targets for toxicity of these inorganic compounds are dissimilar, summation of the HQs may be inappropriate. Therefore, exposure to Gallia groundwater from well F-31G associated with its use as a potable water supply is not anticipated to result in adverse noncancer health effects.

Carcinogen Weight-of-Evidence Classification

As indicated above, one limitation to the procedure for summing cancer risks for multiple chemicals is that the procedure gives as much weight to chemicals assigned to class B (probable human carcinogens) or C (possible human carcinogens) as to class A carcinogens (known human carcinogens). For class C carcinogens, for which there is limited evidence of carcinogenicity in animals and inadequate or lack of human data, the evidence that the chemical is a human carcinogen is the weakest.

Six chemicals detected in Quadrant III media at PORTS are class C carcinogens. These are 1,1-dichloroethane, 1,1-dichloroethene, isophorone, 2-methylphenol (o-cresol), 4-methylphenol (p-cresol), and 1,1,2-trichloroethane. Additionally, U.S. EPA has not adopted a final position on the weight-of-evidence classification for trichloroethene (see Appendix H.5).

A review was performed of potential risks for each SWMU to determine the extent to which class C carcinogens and trichloroethene (with no classification) contribute to overall risk. Only 1,1-dichloroethene, 1,1,2-trichloroethane, and trichloroethene present risks in excess of 10^{-6} in any of the Quadrant III SWMUs. In groundwater (Gallia aquifer) from the X-530A unit, potential risks posed by 1,1,2-trichloroethane and trichloroethene under the future on-site residential scenario comprise approximately 86 percent of the total risk (5×10^{-6}) associated with organic chemicals in groundwater. In groundwater from both the Gallia and Berea aquifers at the X-616 unit, potential risks posed by 1,1-dichloroethene and trichloroethene under the future on-site residential scenario comprise approximately 97 to 100 percent of the total risk associated with organic chemicals in groundwater; total potential risks posed by organic chemicals in Gallia groundwater from the Gallia and Berea aquifers at this unit are 2×10^{-4} and 6×10^{-6}, respectively. Finally,

in groundwater (Gallia aquifer) from the X-740 unit, potential risks posed by 1,1-dichloroethene, 1,1,2-trichloroethane, and trichloroethene under the future on-site residential scenario comprise about 99 percent of the total risk associated with organic chemicals in groundwater (1×10^{-2}).

Given the significance of risks posed by Class C carcinogens (and trichloroethene, for which a weight-of-evidence classification has not been determined), it may be appropriate for risk managers to consider the uncertainty in the cancer assessments for organic constituents in groundwater from the X-530A, X-616, and X-740 units in the development of remedial alternatives.

6.5.4.3 Summary of Uncertainties

The majority of uncertainties discussed above are likely to lead to overestimation of potential risks associated with constituents present at PORTS. Because the assumptions and variable values used in the BRA about which there is associated uncertainty are not independent, and because it is difficult to ascribe to most uncertainties a magnitude by which potential health risk may be under or overestimated, an overall estimate of the extent to which actual potential health risk may be overstated cannot be developed. In general, actual risks, if any, could be several orders of magnitude less than presented here.

As stated previously, risks estimated using the methods of risk assessment prescribed by regulatory agencies are not actuarial. Given the uncertainties in risk assessment, the risk estimates derived herein may be of greatest value for establishing relative risk, i.e., by comparison to other risks derived using similar risk assessment methods and similarly conservative assumptions.

6.6 Preliminary Ecological Risk Assessment (PERA)

6.6.1 Objectives and Scope

A "preliminary ecological risk assessment" (PERA) was conducted for Quadrant III following the methodology developed by Suter (1990) for the Environmental Sciences Division (ESD) of the Oak Ridge National Laboratory (ORNL). This methodology, which was further developed for PORTS by Kramel, Hull, and Bonczek of ORNL and described in the Quadrant IV RFI Work Plan (Geraghty & Miller, Inc., 1992g) was used as the principal guidance for preparing the PERA for Quadrant III. The same approach was used to prepare PERAs for Quadrants I, II, and IV.

The ecological risk assessment process, as developed by ORNL and described in the Quadrant IV RFI Work Plan (Geraghty & Miller, Inc., 1992g), is a two step procedure. The first step is to conduct a separate PERA for each quadrant. The PERA is conducted on a quadrant-wide, watershed, and solid waste management unit (SWMU) level. This is ideally followed by a facility-wide Baseline Ecological Risk Assessment (BERA). The purposes of the PERA are: (1) to compile existing fate, exposure and ecotoxicity information (including that collected during the RFI); and (2) to evaluate this information, using a screening process, to focus the facility-wide BERA. Specifically, the PERA identifies and screens potential constituents of concern (COCs) for ecological risks for each identified SWMU. Further, the PERA identifies the watersheds within the quadrant and determines which SWMUs are located within each watershed. Finally, the PERA presents an overview of the biotic community types within the quadrant. To accomplish the PERA, screening benchmarks for ecological effects are developed for each chemical constituent detected in each environmental medium evaluated during the RFI (i.e., sediment, water, and soil).

The objective of this section is to present the results of a PERA performed for Quadrant III at the PORTS facility. The remainder of Section 6.6 is organized as follows:

Section 6.6.2. Physical characterization of PORTS and Quadrant III. This section describes the physical characteristics of the area; source units/SWMUs; and integrator units (i.e., watersheds).

Section 6.6.3. Ecological characterization of Quadrant III. Identification and characterization of local biotic communities and special resources are discussed.

Section 6.6.4. Identification of constituents of concern (COCs) and sources of contamination. This section provides a description of chemical data, establishment of RME concentrations, and a discussion of COCs relative to SWMUs and watersheds.

Section 6.6.5. Environmental fate of COCs.

Section 6.6.6. Derivation of screening benchmarks .

Section 6.6.7. Comparison of COCs with screening benchmarks. Comparison is made of hazard benchmarks to measured levels in each environmental medium to identify relative risk levels and categorization of COCs, SWMUs and watersheds based on screening benchmarks and relative risk levels.

Section 6.6.8. Conclusions

6.6.2 Physical Characterization of PORTS and Quadrant III

PORTS is located in south-central Ohio (Pike County), approximately one mile east of the Scioto River. The facility occupies approximately 6.3 square miles in a predominantly rural area. The overall size of the area, diversity of habitat types present, and rural surroundings allow a considerable diversity of fish and wildlife species to inhabit the site. The nearest town is Piketon (about 5 miles north), which had a population of 1,900 in 1986 (Energy Systems, 1990).

The site and its immediate environs consist of a relatively flat, broad valley that is oriented north-south and is approximately 120 feet higher in elevation than the Scioto River. There are low lying hills east and west of the site that contain drainage areas or other small valleys. Within a 5-mile radius of the site, land use is divided between farmland (24,430 acres including cropland, pasture and commercial woodlots) and forests (24,416 acres) with some hills and terraces utilized for cattle pasture. Within this same area, only 206 acres are classified as urban (Energy Systems, 1990).

The following description of Quadrant III is based on a site visit and a wetland survey report for the quadrant (Snyder, 1992, in Appendix H.8). Figure 6.2 shows the land use in Quadrant III at PORTS. Quadrant III covers most of the mid-to-northwestern portion of the PORTS site. It is primarily flat but has a hill in the northern portion of the quadrant. Neither of the two major streams associated with the PORTS facility (Little Beaver Creek and Big Run Creek) traverse Quadrant III. The Perimeter Road can be viewed as a boundary dividing the developed (eastern half) and undeveloped (western half) areas of the quadrant. The area east of the Perimeter Road is flat, dominated by buildings, storage areas, roadways, parking lots and maintained lawns. West of the Perimeter Road are two man-made ponds (X-2230N and X-230J5), the West Drainage Ditch (WDD), and

the Don Marquis electric substation (DMRQ) (on the hill in the northern portion). The main access road to the PORTS facility runs through the western portion of Quadrant III. In addition, this western sector includes old field and second-growth deciduous forest habitats.

6.6.2.1 Identification of Source Units (SWMUs) Considered in the PERA

Section 4.0 of the RFI provides details on the 19 SWMUs identified in Quadrant III; 15 of these SWMUs are considered in this PERA (Table 6.272). SWMUs RCW, STSW, and SASW are not considered because they are dispersed throughout the quadrant; data from individual sample points in these SWMUs were assigned to other SWMUs where possible and were included in the overall evaluation of the quadrant. SWMU X-616 was not considered because only groundwater was sampled and this is not considered a direct pathway to ecological receptors.

There are several differences in the way the available RFI data have been used in the PERA as compared with the human health baseline risk assessment (BRA):

- Only soil data collected at depths of zero to two ft were used in the PERA. Soil data from samples deeper than this were not considered relevant to ecological receptors. In the human health BRA, potential risks associated with soil data from 0 to 10 ft were evaluated.

- As noted above, groundwater data were not considered in this PERA because: (1) it is assumed that the groundwater is hydrologically linked to the surface waters, which have already been sampled and addressed in the PERA; and (2) groundwater, which is present on average across the PORTS

site at a depth of 16 feet, is not generally recognized as a viable exposure pathway for biota beyond its link to surface water. Surface water data are considered in the PERA. Future migration of groundwater plumes and their discharge to surface water would be considered in a more rigorous assessment, such as a BERA. Groundwater data were considered in the human health BRA (see Section 6.2.3). SWMU X-616 was eliminated from consideration in the PERA because it was sampled for groundwater only. However, an investigation of groundwater flow in the quadrant shows that it ultimately discharges into the unnamed tributary leading from the X-230J5 holding pond (also referred to as the Western tributary) (Section 2.2.3.1). Thus, potential risks associated with SWMU X-616 are addressed as part of the evaluation of X-230J5.

- Data likely representative of possible localized contamination (i.e., "hot spots") were included in the quadrant-wide data set for the PERA, but were not included in the quadrant-wide data set for the human health BRA (see Section 6.2.3). Because the PERA is a screening level assessment, "hot spots" were included in order to be conservative.

6.6.2.2 Identification of Integrator Units (Watersheds)

The West Drainage Ditch (WDD) and its associated holding pond (X-2230N, approximately one-quarter acre in area) are the major water bodies located within Quadrant III. A smaller holding pond (X-230J5, approximately one-tenth acre in area) is adjacent to the larger pond and receives water intermittently from a series of drainage ditches to the east of Perimeter Road. Overflow from these two ponds is to WDD that flows west from the PORTS facility and eventually to the Scioto River. There are also three small waste

ponds, one each in the northern, eastern and southern portions of DMRQ. They presumably collect surface runoff from the DMRQ hill; evaporation and possible overflow during heavy precipitation are possible migration pathways (towards Little Beaver Creek in Quadrant IV).

As shown in Figure 6.3, there are three identifiable watersheds in Quadrant III. Integrator unit "A" is comprised of the northern section of the quadrant, which drains northwest toward Little Beaver Creek. Unit "B" is the portion of Quadrant III (approximately 90 percent of the total quadrant area), which is drained by the Western Drainage Ditch (WDD). Unit "C" drains to the southern portion of the quadrant. Table 6.273 lists each SWMU considered in the PERA and its relationship to one or more of the identified watersheds. In general, SWMUs were assumed to drain to storm water sewers. There are no identifiable creeks or streams that drain units "A" and "C", but based on the topography of the area, all of Quadrant III drainage water eventually discharges to the Scioto River.

6.6.3 Ecological Characterization of Quadrant III

Most of the information presented in this section is not specific to Quadrant III. Quadrant-specific information was included when available.

6.6.3.1 Wetlands

A wetlands survey was conducted for Quadrant III between February 29 and March 3, 1992 (Snyder, 1992; see Appendix H.8). The report identifies wetlands present in the quadrant based on the three-parameter approach (FICWD, 1989): 1) hydrophytes (wetland-associated plants), 2) the hydric nature of the soil (the extent of anaerobic

conditions in the root zone), and 3) the hydrology. The report concluded that ..."Due to the highly developed character of the site, no undisturbed, naturally occurring wetlands were identified." Certain areas, however, did meet the criteria for defining a wetland. These include emergent wetlands primarily associated with alluvial soils in the stream channel of the west drainage ditch, in other drainage ditches and swales, in small land depressions formed by construction/fill activities, and in ponds. A more recent wetlands survey of the entire site was also conducted in 1994 by Adams and Butler (see Appendix H.8).

6.6.3.2 Vegetative Cover

The eastern portion of Quadrant III (inside the Perimeter Road) is comprised primarily of buildings, roads, and other industrial areas. There is limited vegetation except for maintained lawns; much of the area is covered by pavement.

The southwestern portion of the quadrant is dominated by vegetation associated with old agricultural fields including grasses, goldenrods, asters, lespedeza, multiflora rose, blackberries, and numerous species of upland forbs. The west-central portion of the quadrant includes the WDD drainage area. It is dominated by a second-growth deciduous community (oak, hackberry, sycamore, box elder, red maple and Japanese honeysuckle trees) (Snyder, 1992, Appendix H.8). The northwest portion of the quadrant around DMRQ is undeveloped and also consists primarily of a second-growth deciduous forest community. This portion of the quadrant was not surveyed by Snyder (1992, Appendix H.8).

According to Kornegay et al. (1991), as cited in U.S. DOE (1993), all of the forests on the facility are second growth and the dominant forest cover type is oak-hickory forest.

Other species present include maple, ash, pine, and sycamore. The U.S. DOE also lists the following subcanopy species: shining sumac, poison sumac, poison ivy, and blackberry.

6.6.3.3 Terrestrial Wildlife

An extensive terrestrial wildlife survey of the PORTS reservation was conducted in the mid-1970s (Battelle, 1976a, as cited in U.S. DOE, 1993). Based on this survey, the wildlife species present on the PORTS site are typical of those normally found in similar habitats throughout south-central Ohio. Quadrant III and adjacent areas provide several habitat types including open fields, deciduous forest community, small ponds and intermittent drainage ditches/creeks. However, the relatively sparse vegetative cover and high human activity levels inside the Perimeter Road provide limited habitat for most wildlife species within this industrialized area.

6.6.3.3.1 Mammals

Gottschang (1981) lists the species of mammals found in Pike County, and U.S. DOE (1993) summarizes information on fauna-sightings at PORTS. The data in Gottschang (1981) show that 47 species of mammals have ranges that include the PORTS facility. According to the latest reports from Ohio Department of Natural Resources (ODNR), Pike County ranked 85th out of 89 among Ohio counties in overall fur bearer harvest (1985-1986 season), and 35th in deer harvest (1989-1990 season).

Species of Mammals Identified in Pike County, Ohio	
Classification	**Species[1]**
Marsupials	Virginia opossum[2,3]
Insectivores	masked shrew, smoky shrew, short-tailed shrew[3], least shrew, hairy-tailed mole, eastern mole
Bats	little brown bat, Keen's bat, Indiana bat, silver-haired bat, eastern pipistrelle, big brown bat, red bat, hoary bat, evening bat
Rabbits and Hares	Eastern cottontail[3]
Rodents	Eastern chipmunk[3], woodchuck[3], striped gopher, gray squirrel[3], fox squirrel[3], red squirrel, southern flying squirrel, beaver[2], eastern harvest mouse, deer mouse, white-footed mouse[3], pack rat, field mouse, prairie vole, pine mouse, muskrat[2], southern bog lemming, brown rat, house mouse, meadow jumping mouse
Herbivores	white-tailed deer[2,3]
Carnivores	coyote, red fox[2], gray fox[2], raccoon[2], least weasel, long-tailed weasel[2,3], mink[2], badger, striped skunk

1 Obtained from Gottschang (1981).
2 The presence of this species in Pike County was confirmed from 1985-86 trapping records obtained from the ODNR.
3 Listed in U.S. DOE (1993) as having been observed on the PORTS reservation.

6.6.3.3.2 Birds

Peterjohn and Rice (1991) list the species of birds with confirmed, probable, or possible breeding records in Pike County, Ohio; this list is presented in the following table. According to U.S. DOE (Battelle, 1976a, as cited in U.S. DOE, 1993), 116 avian species have been observed at the PORTS facility including both year-round residents and migratory species. Ninety-nine species are known to breed within Pike County, "...any of which may be found on the PORTS site"; these species of birds are listed in Table 3.9 of U.S. DOE (1993).

Species of Breeding Birds Identified in Pike County, OH (Peterjohn and Rice, 1991)		
Classification	**Breeding Status**	Species
Birds of prey	Confirmed	broad-winged hawk, red-tailed hawk, american kestrel, great horned owl
	Probable	sharp-shinned hawk, cooper's hawk, red-shouldered hawk, eastern screech-owl, barred owl, common nighthawk
	Possible	turkey vulture
Water birds	Confirmed	wood duck, mallard, belted kingfisher, killdeer
	Probable	--
	Possible	--
Field birds	Confirmed	ruffed grouse, wild turkey[1], northern bobwhite, rock dove, mourning dove, chuch-will's-widow, whip-poor-will, chimney swift, red-bellied woodpecker, downy woodpecker, hairy wookpecker, northern flicker, pileated woodpecker, eastern wood-pewee, acadian flycatcher, eastern phoebe, great crested flycatcher, eastern kingbird, purple martin, tree swallow, northern rough-winged swallow, bank swallow, barn swallow, blue jay, american crow, carolina chickadee, tufted titmouse, white-breasted nuthatch, carolina wren, bewick's wren, house wren, blue-gray gnatcatcher, eastern bluebird, wood thrush, american robin, gray catbird, northern mockingbird, brown thrasher, cedar waxwing, european starling, white-eyed vireo, yellow-throated vireo, warbling vireo, red-eyed vireo, blue-winged warbler, yellow warbler, yellow-throated warbler, prairie warbler, cerulean warbler, black-and-white warbler, american redstart, worm-eating warbler, ovenbird, Louisiana waterthrush, Kentucky warbler, common yellowthroat, hooded warbler, yellow-breasted chat, summer tanager, scarlet tanager, northern cardinal, indigo bunting, rufous-sided towhee, chipping sparrow, field sparrow, grasshopper sparrow, henslow's sparrow, song sparrow, red-winged blackbird, eastern meadowlark, common grackle, northern oriole, American goldfinch, house sparrow
	Probable	green-backed heron, american woodcock, black-billed cuckoo, yellow-billed cuckoo, ruby-throated hummingbird, red-headed woodpecker, willow flycatcher, horned lark, northern parula, pine warbler, rose-breasted grosbeak, blue grosbeak, dickcissel, vesper sparrow, savannah sparrow, bobolink, brown-headed cowbird, orchard oriole, house finch
	Possible	prothonotary warbler

[1] The presence of this species in Pike County was confirmed by 1989-90 hunting records obtained from the ODNR.

6.6.3.4 Reptiles and Amphibians

The U.S. DOE (1993) states that 28 species of reptiles and 30 species of amphibians have ranges that include the PORTS facility; the most common reptile species are the eastern box turtle, black rat snake, and northern black racer. In addition, the following reptiles have been observed on the PORTS facility (Battelle, 1976a, as cited in U.S. DOE, 1993): snapping turtle; map turtle; midland painted turtle; eastern spiny softshell turtle; northern water snake; eastern garter snake; and the eastern hognose snake. Among the most common amphibians for this region of Ohio are the American toad, and northern dusky salamander. In addition, the following amphibians have been observed on the PORTS reservation (Battelle, 1976a, as cited in U.S. DOE, 1993): bullfrog; northern leopard frog; northern spring peeper; and fowler's toad.

6.6.3.5 Insects

Battelle (1976a, as cited in U.S. DOE, 1993) reports collecting approximately 500 species of insects in various habitats at the PORTS facility. The following insect orders were the most prevalent: Homoptera (cicadas, aphids, and scale insects), Hymenoptera (ants, wasps, and bees), Diptera (flies, gnats, and mosquitoes), and Coleoptera (beetles). U.S. DOE (1993) concluded the following:

> Greatest numbers of insects and highest diversity indexes were found in pine forests, old fields with diverse herbaceous vegetation, and hardwood forests with dense understory. Open forest areas tended to have intermediate diversity indexes and numbers of insects. Low diversity indexes and low numbers of insects were found in dense stands of fescue, sparsely vegetated fields, and grazed woodlots. One herbaceous fencerow was sampled and was found to have high numbers of insects but a low diversity index.

6.6.3.6 Aquatic Organisms

Numerous species of fish and aquatic invertebrates inhabit the waters of south-central Ohio. U.S. DOE (1993) cites Kornegay et al. (1991) as reporting 58 species of fish present in streams in the immediate vicinity of the PORTS facility. Trautman (1981) has compiled information on the species of fish that inhabit specific bodies of water, including fish in the Scioto River drainage in Pike County.

There has been no survey of aquatic organisms in either the WDD, the two holding ponds, or the three waste ponds in Quadrant III. It is unlikely that these water bodies would contain significant numbers of fish because of intermittent flows, shallow depths, and related habitat limitations and therefore a list of fish species was not included. However, it is possible that some macroinvertebrates, reptiles, and amphibians inhabit these areas.

6.6.3.7 Threatened and Endangered Species

Appendix H.9 contains a copy of a document entitled "Technical Memorandum for Threatened and Endangered Species Habitat Survey." U.S. DOE (1993) discusses other possible threatened or endangered species that may be present in or around the facility. These species are presented in Table 6.274. This information on threatened and endangered species will be useful in the identification of indicator species for consideration in quantifying ecological risk at PORTS during the facility-wide BERA.

6.6.4 Identification of Constituents of Concern (COCs) and Sources of Contamination

This section provides a qualitative discussion of contamination in Quadrant III. Chemicals with an RME concentration below background were dropped from the assessment (only tentative background data were available for inorganics in soil). Tables are provided for each SWMU with summary statistics that were used in Section 6.6.7 for comparison to screening benchmarks. The location of quadrant-wide maximum concentrations and COCs unique to a SWMU in a given environmental medium are presented. Finally, all sample points were assigned to a watershed so that sources of contamination within a watershed could be assessed.

6.6.4.1 Constituents of Concern (COCs)

Soil, sediment, surface water and groundwater samples were collected from in and around the SWMUs in Quadrant III and analyzed for various organic COCs, inorganics COCs, and radionuclides. The analyses performed on each sample are discussed in Chapter 4.0 and summarized in Section 6.6.4.3. The numbers of samples, by environmental medium, for each SWMU evaluated in the PERA are presented in Table 6.273.

Tables 6.275 and 6.276 present the calculated quadrant-wide RME concentrations (by environmental medium) for each of the constituents detected in the quadrant. For each constituent, the RME concentration is represented by either the 95 percent upper confidence limit (UCL) of the quadrant-wide mean concentration of the log-normally transformed data or by the maximum reported value, whichever value was less (see Section 6.3.4 for the details of calculating RME concentrations). For the analysis of individual SWMUs, maximum reported values were always used as the RME concentrations because of the

relatively small data sets for each of the SWMUs. The RME values are compared to the adverse effect screening benchmarks, established for each of the environmental media, to identify potential risks within the SWMU, quadrant, or watershed.

A total of 26 inorganic COCs were detected in at least one environmental medium (sediment, soil [0-2 ft depth only] and surface water) and 21 were detected in all three environmental media. Twenty-three inorganic COCs were detected in sediment, 22 were detected in surface water, and 25 were detected in soil (Table 6.275).

A total of 60 organic COCs were detected in sediment, surface water, or soil samples collected in Quadrant III. Most of the organic COCs were detected in soil samples (49 of 60). Twenty-seven organic COCs were detected in sediment and 19 were detected in surface water. Seven organic COCs were detected in all three environmental media (anthracene, benzo[a]anthracene, chloroform, fluoranthene, phenanthrene, pyrene, and xylene). Twenty-one organic COCs were detected in soil only, nine in surface water only, and two in sediment only. Eighteen organic COCs were detected in soil and sediment but not surface water. Three organic COCs were detected in soil and surface water but not sediment. All compounds that were detected in sediment and surface water were also detected in soil (Table 6.276).

As per the approved work plans for Quadrant III, the radiological parameters for which samples were routinely analyzed included total uranium and technetium. Uranium and technetium were detected in sediment and soil but not surface water.

6.6.4.2 Background Levels for COCs

The first step in establishing which chemicals may actually represent an ecological concern in Quadrant III is to consider natural background levels in the area. As in the human health BRA, consideration of background was based on the tentative background analysis available at the time of the PERA. Tentative background values were available for all inorganics in soils except antimony.

RME concentrations calculated using the quadrant-wide soil data set were compared to tentative background levels (Table 6.277). Quadrant-wide RME concentrations for 17 of the 26 inorganic COCs found in soils were below tentative background levels (categories 1 and 2 in Table 6.277) and these 17 COCs were dropped from further analysis in the quadrant-wide PERA[9]. Background levels were not available for four inorganic COCs (antimony, cyanide, lithium, and selenium) and these COCs were retained for the quadrant-wide PERA analysis. RME concentrations for calcium, magnesium, silver, and sodium were above tentative background levels and these compounds were also considered in the quadrant-wide PERA analysis. The RME concentration for uranium was below background in soil, and therefore, uranium was dropped from further quadrant-wide analysis. A soil background level does not exist for technetium; therefore, technetium was considered in the PERA quadrant-wide analysis.

The RME concentration used in the analysis of individual SWMUs was the maximum detected concentration in the given SWMU; therefore, background levels were compared to maximum detected levels for each inorganic and radionuclide soil COC at a

[9]Note that the RME concentration in the quadrant-wide analysis was calculated as the 95 percent upper confidence limit on the mean, or the maximum detected level, whichever value is less.

SWMU. When the maximum value was below the background level, the COC was dropped from further analysis in the PERA. Twenty-three of the 26 inorganic COCs were included in the SWMU by SWMU analysis of soils; concentrations of aluminum, manganese, and vanadium were below tentative background in all Quadrant III SWMUs. Thallium was not detected in Quadrant III soils.

Background data were not available for COCs detected in sediment or surface water. All COCs detected in these environmental media were considered in this PERA.

6.6.4.3 Discussion of COCs by SWMU

The following SWMU by SWMU description of the analytical data identifies which constituents were detected in sediment, surface water, and soil (0 to 2 ft.) at each SWMU. Table 6.278 provides a list of those COCs found at a single SWMU, by environmental medium. This table of "unique" COCs facilitates assignment of contamination by a COC to a single SWMU. Table 6.279 to 6.300 provide SWMU-specific data for all detected COCs by environmental medium.

X-230J3 West Environmental Sampling Building and Intermittent Containment Basin

Six soil samples were taken from X-230J3 (three Phase I and three Phase II). All Phase I samples and one Phase II sample were analyzed for TCL/TAL and RADs. The remaining two Phase II samples were analyzed for VOCs, SVOCs, metals, and RADs. Nineteen inorganic COCs (5 with maximum detections above background), 22 organic COCs, and 1 radionuclide were detected in soil. These data are presented in Table 6.279.

X-230J5 West Holding Pond and Oil Separation Building

Five Phase I sediment samples were taken from X-230J5 (TCL/TAL and RADs analyses). Nineteen inorganic COCs, 20 organic COCs, and 2 radionuclides were detected in sediment. No Phase II samples were collected. These data are presented in Table 6.280.

Two Phase II soil samples were taken from X-230J5 (TCL/TAL and RADs analyses). Seventeen inorganics (none with maximum detections above background), two organics, and one radionuclide were detected in soil. No Phase I soil samples were collected. These data are presented in Table 6.281.

X-326 Process Building

Four Phase II soil samples were taken from X-326 and analyzed for chromium and zinc. Both chromium and zinc were detected; neither maximum detection exceeded background. No Phase I soil samples were collected. These data are presented in Table 6.282.

X-330 Process Building

Eight soil samples were taken from X-330 (two Phase I and six Phase II). Phase I samples were analyzed for chromium; Phase II samples were analyzed for chromium and zinc. Both chromium and zinc were detected, but neither maximum detection exceeded background. These data are presented in Table 6.283.

X-530A Switch Yard

Twenty-eight soil samples were taken from X-530A (24 Phase I and 4 Phase II). All 24 Phase I samples were analyzed for TCL/TAL; 15 of these were also analyzed for RADs. All four Phase II samples were analyzed for chromium and zinc; two samples were also analyzed for SVOCs and PCBs. Twenty-two inorganic COCs (twelve with maximum detections above background), 31 organic COCs, and 1 radionuclide were detected in soil. These data are presented in Table 6.284.

X-615 Abandoned Sanitary Sewage Treatment Facility

Ten soil samples were taken from X-615 (seven Phase I and three Phase II). All samples were analyzed for TCL/TAL and RADs. Twenty-one inorganic COCs (10 with maximum detections above background), 19 organic COCs, and 2 radionuclides were detected in soil. These data are presented in Table 6.285.

X-740 Waste Oil Handling Facility

Eleven Phase I soil samples were taken from X-740. Samples were analyzed for both TCL/TAL and RADs. Twenty-one inorganic COCs (10 with maximum detections above background), 15 organic COCs, and 1 radionuclide were detected in soil. No Phase II soil samples were taken. These data are presented in Table 6.286.

X-744N Warehouses

Six Phase I soil samples were taken from X-744N. All samples were analyzed for TCL and lithium, five samples were also analyzed for RADs, and four samples were also

analyzed for TAL. Twenty inorganic COCs (5 with maximum detections above background), 16 organic COCs, and 1 radionuclide were detected in soil. No Phase II soil samples were taken. These data are presented in Table 6.287.

X-744S Lithium Storage Warehouses

Twenty Phase I soil samples were taken from X-744S. All samples were analyzed for TCL and lithium; 12 samples were also analyzed for TAL and RADs. Twenty-one inorganics (6 with maximum detections above background), 22 organic COCs, and 1 radionuclide were detected in soil. No Phase II soil samples were taken. These data are presented in Table 6.288.

X-745C West Cylinder Storage Yard

Twenty-two soil samples were taken from X-745C (16 Phase I and 6 Phase II). Phase I samples were analyzed for TCL/TAL and RADs; Phase II samples were analyzed for SVOCs and PCBs. Twenty-one inorganic COCs (17 with maximum detections above background), 29 organic COCs, and 2 radionuclides were detected in soil. These data are presented in Table 6.289.

X-2230N West Holding Pond No. 2

Three Phase I sediment samples were taken at X-2230N (TCL/TAL and RADs analyses). Nineteen inorganic COCs, 17 organic COCs, and 2 radionuclides were detected in sediment. No Phase II sediment samples were taken. These data are presented in Table 6.290.

One Phase I surface water sample was taken at X-2230N (APPIX and RADs analyses). Two inorganic COCs were detected in surface water. No Phase II surface water samples were taken. These data are presented in Table 6.291.

Two Phase II soil samples were taken from X-2230N (TCL/TAL and RADs analyses). Sixteen inorganic COCs (two with maximum detections above background), two organic COCs, and one radionuclide were detected in soil. No Phase I soil samples were taken. These data are presented in Table 6.292.

X-6619 & X-6614E Sewage Treatment Facility

Nine soil samples were taken from X-6619 and X-6614E (four Phase I samples and five Phase II samples). Phase I samples were analyzed for TCL/TAL and RADs; Phase II samples were analyzed for inorganic COCs. Nineteen inorganic COCs (two with maximum detections above background), one organic COC, and one radionuclide were detected in soil. These data are presented in Table 6.293.

Initial Construction Bulk Fuel Storage Area; X-7725 Recycle Assembly Building; and X-7745R Recycle Assembly Storage Yard (BFS)

Sixteen soil samples were taken from BFS (5 Phase I samples and 11 Phase II samples). Three Phase I samples were analyzed for TCL/TAL and RADs, and two Phase I samples were analyzed for BTEX. Two Phase II samples were analyzed for SVOCs and nine Phase II samples were analyzed for TCL/TAL and RADs. Twenty inorganic COCs (10 with maximum detections above background), 11 organic COCs, and 1 radionuclide were detected in soil. These data are presented in Table 6.294.

Don Marquis Substation Associated Containment Ponds and Drainage Ditches (DMRQ)

Nine sediment samples were taken from DMRQ (six Phase I and three Phase II). Four Phase I samples were analyzed for TCL, and two Phase I samples were analyzed for TCL/TAL and RADs. One Phase II sediment sample was analyzed for TCL/TAL and RADs, and two Phase II sediment samples were analyzed for RADs. Nineteen inorganic COCs, two organic COCs, and one radionuclide were detected in sediment. These data are presented in Table 6.295.

Seven Phase I surface water samples were taken from DMRQ. All samples were analyzed for TCL and five samples were analyzed for TAL and RADs. Twenty-two inorganic COCs and six organic COCs were detected in surface water. No Phase II surface water samples were taken. These data are presented in Table 6.296.

Twenty Phase I soil samples were taken from DMRQ. All samples were analyzed for TCL and 12 samples were analyzed for TAL and RADs. Twenty inorganic COCs (11 with maximum detections above background), 19 organic COCs, and 1 radionuclide were detected in soil. No Phase II samples were taken. These data are presented in Table 6.297.

West Drainage Ditch (WDD)

Nineteen Phase I sediment samples were taken from WDD. All sediment samples were analyzed for TCL/TAL and RADs; in addition, one was analyzed for TOX. Twenty-one inorganic COCs, 24 organic COCs, and 2 radionuclides were detected in sediment. No Phase II sediment samples were taken. These data are presented in Table 6.298.

Sixteen surface water samples were taken from WDD (2 Phase I and 14 Phase II). All Phase I and 9 Phase II samples were analyzed for APPIX and RADs. The remaining three Phase II samples were analyzed for TCL/TAL and RADs. Eleven inorganic COCs and 15 inorganic COCs were detected in surface water. These data are presented in Table 6.299.

Three Phase I soil samples were taken from WDD (TCL/TAL and RADs analyses). Eighteen inorganic COCs (none with maximum detected concentrations above background), one organic COC, and one radionuclide were detected in soil. No Phase II samples were taken. These data are presented in Table 6.300.

6.6.4.4 COCs by SWMUs (Location of Maximum Values)

Tables 6.301 and 6.302 list the locations of the maximum levels of inorganic, radionuclide, and organic COCs, by SWMU. As shown in the table below, WDD had the highest total number of maximum COC values (58) among the SWMUs, accounting for 34 percent of the total number of maxima (all media). Only two SWMUs (X-326 and X-330) had no maximum values in any of the sampled media.

SWMUs With the Highest Number of Maximum COCs							
	Inorganics and Radionuclides			Organics			
SWMU	Sediment	Water	Soil	Sediment	Water	Soil	TOTAL
WDD	20	2	0	23	13	0	58
DMRQ	4	20	2	1	6	4	37
X-230J3	NS[1]	NS	1	NS	NS	18	19
X-530A	NS	NS	4	NS	NS	10	14
X-745C	NS	NS	6	NS	NS	3	9
X-740	NS	NS	5	NS	NS	2	7
X-615	NS	NS	5	NS	NS	1	6
X-744N	NS	NS	1	NS	NS	4	5
X-744S	NS	NS	1	NS	NS	4	5
X-2230N	1	0	0	2	0	1	4
BFS	NS	NS	1	NS	NS	2	3
X-230J5	1	NS	0	1	NS	0	2
X-6619	NS	NS	2	NS	NS	0	2
X-326	NS	NS	0	NS	NS	0	0
X-330	NS	NS	0	NS	NS	0	0
Total for all SWMUs	26	22	28	27	19	49	171

[1] NS = No samples taken for this SWMU for this medium.

For inorganic COCs, WDD had the greatest number of maximum values in sediment (20; 77 percent of all inorganic sediment maxima), DMRQ had the greatest number in surface water (20; 91 percent of all inorganic surface water maxima), and X-745C had the greatest number in soil (6; 21 percent of all inorganic soil maxima). For radionuclides, the maximum concentration of technetium in sediment was detected at WDD; the maximum concentration in soil was detected at X-615. The maximum concentration of uranium in

sediment was detected at WDD; the maximum concentration in soil was detected at X-230J3. No radionuclides were detected in surface water. For organic COCs, WDD had the greatest number of maximum values in sediment (23; 85 percent of all organic sediment maxima) and surface water (13; 68 percent of all organic surface water maxima). X-230J3 had the greatest number of maximum values in soil (18; 37 percent of all organic soil maxima).

6.6.4.5 Unique COCs by SWMU

Table 6.278 provides a list of the "unique COCs" by SWMU. Unique COCs are those detected in only a single SWMU for a given environmental medium. As summarized in the table below, DMRQ had the highest total number of unique COCs (19) among the SWMUs, which accounted for 35 percent of the total number of unique COCs (there were 54 unique COCs in all media combined). Five of the 15 SWMUs (X-326, X-330, X-740, X-744S, and X-6619) had no unique COCs in any of the sampled media.

There were unique COCs in each constituent class and in each environmental medium. All four SWMUs at which sediments were sampled had at least one unique COC in sediment. Of the three SWMUs at which surface water was sampled, all but X-2230N had one or more unique COCs in surface water. Seven of the 15 SWMUs (WDD, X-230J5, X-326, X-330, X-740, X-744S and X-6619) did not have unique COCs in soil.

For inorganic COCs, DMRQ, WDD, and X-230J5 had the greatest number of unique COCs in sediment (one each), DMRQ had the greatest number in surface water (11, accounting for all unique inorganic surface water COCs), and X-530A and X-615 had the greatest number in soil (one each). For organic COCs, WDD had the greatest number of unique COCs in sediment (3; 50 percent of all unique organic sediment COCs) and surface

2371

water (13; 76 percent of all unique organic surface water COCs). X-530A had the greatest number of unique COCs in soil (4; 27 percent of all unique organic soil COCs).

SWMUs with the Highest Number of Unique COCs

SWMU	Inorganics			Organics			TOTAL
	Sediment	Water	Soil	Sediment	Water	Soil	
DMRQ	1	11	0	1	4	2	19
WDD	1	0	0	3	13	0	17
X-530A	NS[1]	NS	1	NS	NS	4	5
X-744N	NS	NS	0	NS	NS	3	3
X-2230N	0	0	0	1	0	1	2
X-230J5	1	NS	0	1	NS	0	2
BFS	NS	NS	0	NS	NS	2	2
X-745C	NS	NS	0	NS	NS	2	2
X-230J3	NS	NS	0	NS	NS	1	1
X-615	NS	NS	1	NS	NS	0	1
X-326	NS	NS	0	NS	NS	0	0
X-330	NS	NS	0	NS	NS	0	0
X-740	NS	NS	0	NS	NS	0	0
X-744S	NS	NS	0	NS	NS	0	0
X-6619	NS	NS	0	NS	NS	0	0
Total for All SWMUs	3	11	2	6	17	15	54

[1] NS = No samples taken for this SWMU for this medium.